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TABLE OF CONTENTS

LEADING ARTICLES: Page

The Improvement of the Port of Manzanillo, Mexico (illustrated)..... 157
Cost of Electric Railway Power Production and Transmission in the State of Indiana; A. S. Richey..... 159
The Pintsch Suction Gas Producer (illustrated); S. F. Saeger..... 161
Concrete Floors for Railway Bridges (illustrated)..... 162
Granulated Slag for Ballasted Bridge Floors; E. K. Morse, M. Am. Soc. C. E..... 162
The Efficiency of Waste-Gas Boilers in Connection with Rotary Cement Kilns; A. B. Helbig..... 163
The Convention of the Canadian Society of Civil Engineers (illustrated)..... 166
Tank Locomotives for Suburban Service on American Railways (illustrated)..... 166
Effect of Load Factor on Cost of Electric Power (illustrated); E. M. Archibald..... 169
The Computation of Stresses in the Blackwell's Island Bridge (illustrated); R. C. Strachan..... 170
A Short Subway for Pipe and Wires; John D. Adams..... 172
Method of Assessing Longer Side of Corner Lots for Paving in 16 New Jersey Cities 172

Page

Proposed Passenger Terminal System for Chicago (illustrated)..... 175
The St. Mary's Park Tunnel; New York Central & Hudson River R. R. (illustrated). 176
EDITORIAL..... 173
Ballasted Floors for Railway Bridges—The Plans for the Pittsburg Filter Plant—Sanitation of Contractors' Camps on Water Supply Work.
The Design of the Blackwell's Island Bridge..... 173
Railway Passenger Terminal Stations..... 174
LETTERS TO THE EDITOR.—Calculating Cross-Section Areas, Correction; H. A. Dawley—Comparative Cost of Plain and Reinforced Concrete Retaining Walls (illustrated); Frank A. Bone—Some Elementary Facts Relating to Hygrometry; Lane Johnson—Notes and Queries..... 174
ENGINEERING NEWS OF THE WEEK..... 176
PERSONALS..... 177
ENGINEERING SOCIETIES..... 178

THE IMPROVEMENT OF THE PORT OF MANZANILLO, MEXICO.

One of the most important works of harbor improvement now under way on this continent has been quietly in progress for several years at an obscure town on the Pacific coast of Mexico named Manzanillo, located in the State of Colima, nearly due west from the City of Mexico.

The work, which involves an expenditure of some seven million dollars, is being carried out for the Mexican Government by an American engineer, Edgar K. Smoot, of Washington, D. C., who built the jetties at Galveston, Tex.

At our request, the following account of the works at Manzanillo has been prepared by Mr. A. G. Wilbor, General Auditor for the concessionaire, and we are indebted to him also for the photographs here reproduced.

Manzanillo is situated upon a small bay, which is within or behind a larger bay or indentation of the coast line, having a length along its longer axis of eleven kilometers, with a depth of eight kilometers behind the general coast line. At both extremities of the bay, deep coves have been maintained by the flow of the currents. The southeastern end of the bay is sheltered by a projecting headland.

Over the central ared of the bay the depths are from 30 to 50 meters, deep water extending close to the shores, and shoaling somewhat abruptly upon the sandy beaches which bound it on the north and east.

Although the port is sheltered from the Pacific by the projecting headlands of the Vigia Chico and the intermediate hills, the more sheltered space of the harbor was formerly exposed to the waves of the sea, reaching the harbor by deflection around the headlands, which had a projection of only 200 meters perpendicular to and beyond the beach in front of the town. The shallow submarine banks, the prolongation of the slopes of the headland, still further destroyed the shelter which its projection into deeper water would afford, by retarding the progress and deflecting the waves within the harbor.

In September, 1889, Manzanillo was as isolated as though it were in some African jungle. But that year a short railroad line was built to the City of Colima, 96 kilometers distant, rising in that short distance 1,700 ft. As fast as it can afford to do so the Mexican Central Ry. is building its branch from Guadalajara to Colima to link with the bit of road built by the Mexican National Construction Co., from that town to the port. The Central line is as far now as Tuxpan, but the gap between Tuxpan and Colima, although only 41 miles, will require such expensive constructive work that it will cost fully $5,500,000, Mexican silver, and in order to keep within the maximum grade of 2%, will require 11 bridges and 13 tunnels. Mr. A. A. Robinson, the president of the road, said that possibly work on the unconstructed portion might be taken up this summer. Hampson & Smith, who have the contract, have already an outfit on the ground worth $50,000, ready to make the dirt fly when the word comes.

The future importance of the port of Manzanillo induced the Mexican Government to undertake its improvement. On May 25, 1899, a contract was made for the entire work of improvement at Manzanillo with Col. Edgar K. Smoot, of Washington, D. C. The works consist in general of a breakwater made of stone of large size, to be capped with 30-ton granite blocks and a concrete superstructure 25 ft. in width and 16 ft. in thickness; a stone sea wall along the harbor front, from which ten piers will project; and a canal giving the ocean water access to the Cuyutlan lagoon in the rear of the town.

FIG. 4. VIEW OF MANZANILLO BAY, FROM PROMONTORY, SHOWING WORK IN PROGRESS ON DREDGING AND BUILDING BREAKWATER.

By reason of its tropical situation and immediate physical surroundings, the port of Manzanillo has long been known for its unhealthfulness. The Cuyutlan lagoon, whose shallow waters reached the inhabited portion of Manzanillo, border it on the south and east, being separated by an abrupt range of hills from the San Pedrito or Cacaluta lagoon, together completely surrounding the town within an arc of 180°, and in the direction from which the prevailing winds blow across the port. The waters of the Cuyutlan lagoon had no communication with those of the ocean. During each rainy season the lagoon would fill or rise to a height of nearly a meter above the mean level of the sea, and during the dry season these waters would evaporate rapidly, exposing the bottom and margins of the lagoon to a depth of more than one meter below its flood line level. Borings showed at the bottom of the lagoon seven meters of muddy alluvium interspersed with organic remains of animal and vegetable life. Much the same conditions prevailed in the Cacaluta lagoon and were prejudicial in high degree to the health and comfort of the people of Manzanillo. The heat of a tropical sun, beating upon these extensive areas of saturated and decomposing animal and vegetable matter, produced offensive odors, which were carried through the central portion of the port by all the winds and breezes from southwest to east and northeast.

The Cuyutlan lagoon has a total area of 23 sq. kilometers, comprehending between the mean levels of high and low tides, a volume of 14,807,000 cu. meters of water, subject to tidal flow. The canal of Ventanas has been designed to introduce and discharge 1-14th of this volume during the rise and fall of each tide. This lagoon is divided by a dam at the Strait of Tepalcates, to protect the salt industry of the town of the same name at the eastern edge of the lagoon. The area of the Cacaluta lagoon is about seven square kilometers, with a tidal volume of 3,856,000 cu. meters.

The total expenditure provided for in the contract with Col. Smoot is about $6,700,000. This does not include the wharves and piers which will cost about $1,300,000 additional. All the work save the wharves and piers will be completed during the year of 1905, after which the Government will probably authorize work on the wharves to go forward.

Not less than 1,500,000 tons of blue granite, from the Colomo quarries close by, have so far entered into the rock-work of the Manzanillo harbor improvements. The breakwater, at its extremity, is in water 63 ft. deep, with a width, at the bottom, of 300 ft. Considering its great size, being at the top 25 ft. wide, and that the con-

crete crown is 16 ft. thick, an idea may be formed of the magnitude of the work.

Cement costs, laid down at the port, $9 per barrel. Labor, too, is abnormally expensive. In the old days, when no one at Manzanillo, nor anywhere along the Pacific coast of Mexico, dreamed of port works and intercommunicating railroads, when life was a lazy siesta, enlivened with an occasional fiesta, the Mexican peon in that part of the country would work for 25 cts. a day, and preferred to work only half the week. Now he wants $1.25 to $1.50 per day, and will work only five to eight hours, and refuses to work on feast-days as before.

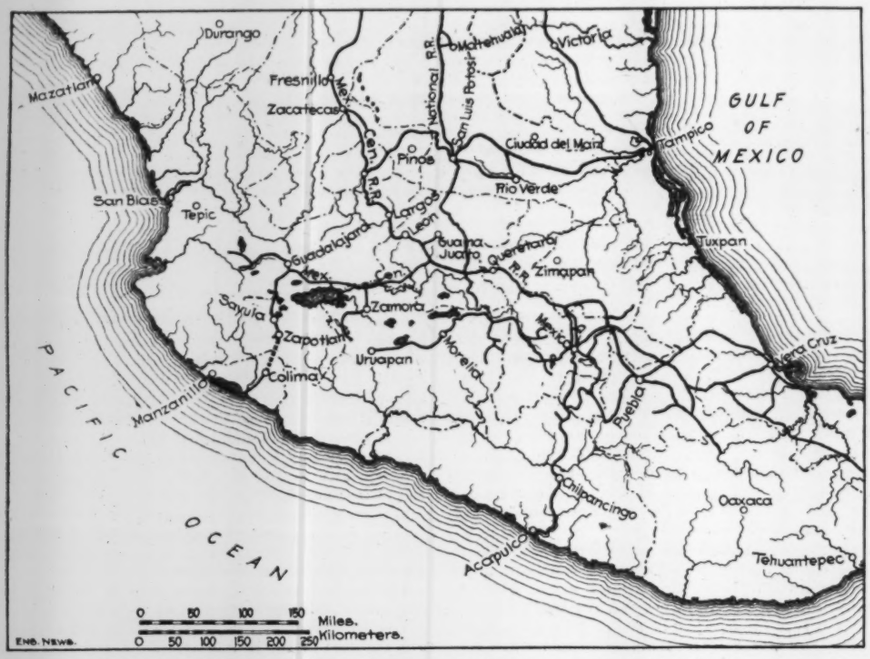


FIG. 1. MAP OF PART OF MEXICO, SHOWING LOCATION OF PORT OF MANZANILLO, WITH REFERENCE TO THE MEXICAN RAILWAY SYSTEM.

On account of the tremendous expense of bringing materials and supplies overland over the awful trails, they are brought from San Francisco by steamer, this having added materially to the cost of the work. Realizing the difficulties and delays incident to such big undertakings at a place cut off from the rest of the world, the Mexican Government has generously augmented the allowances to the contractor and the result fast being demonstrated is a superb harbor. Ships have to make an arc of 180° in order to enter the quiet of the inner harbor, but it is so secure now that for a year or more Colonel Smoot has been able to accommodate sea-going vessels at a temporary wharf on piles, discharging 300 tons a day, even when outside the breakwater the Pacific is swept by storm. This is the first time such an undertaking has been accomplished on the Pacific coast of Mexico.

In designing a breakwater for the protection of the harbor of Manzanillo, it was considered essential to place it in such position that the strength of the counter-currents would be diminished as little as possible, in order to prevent the accumulation of deposits within the harbor. It was given a form concentric with the flow of the eddies within the harbor-area. Its curved form avoids the great depths which would have been encountered along the line of a straight structure sheltering an equal area within the harbor, also thus reducing materially the cost of construction. This curved form of construction presents the greatest resistance to the impact of the waves entering the bay, and by its increased deflection as deeper water is reached diminishes the angle of contact with the incoming waves until its free end brings the breakwater coincident or parallel to their direction, thereby avoiding any obstruction to their course and consequent deflection within the harbor, thus increasing to the utmost limit the area of tranquil water which it is designed to shelter.

Not only does the breakwater already serve as a defense against the sands brought to the port from the coast line, but the wide opening left toward the bay on the north and east permits the free circulation of tidal currents from those directions, thus preventing the deposit within the harbor of such finer silt as may be carried by the waters in suspension.

The crown of the breakwater when completed will be one solid structure, 25 ft. wide and 16 ft. thick, of concrete made either monolithic or of concrete blocks of not less than 30 tons. This mass will be constructed on the rock-substructure that is already completed, reaching to one meter below the level of mean tide. The outer slope of the breakwater is 4 to 1 to the mean tide level and 1¼ to 1 to the depth of eight meters below mean tide; at this level a berme 6 meters wide will be left, continuing the profile to the bottom of the sea with a slope of 1½ to 1. The interior slope has an inclination of 1½ to 1 with a berme of 5 meters in width at 14 meters below mean tide level.

The nucleus of the breakwater is formed with stones of random size, weighing from 25 to 3,000 kilograms, which were allowed to fall into the sea from railroad flat cars. The top of the rock-work and the exterior slope, to the berme, was protected by large blocks of natural stone from the immediate quarries, handled by a great derrick with a capacity of 50 tons. It took nearly four years to bring the breakwater to the point where the cement crown could be undertaken. The work is now all above water, and as soon as the 22,000 barrels of cement now on the ocean en route to Manzanillo arrives, that part of the work will be completed.

The concrete of Portland cement for the crown of the breakwater is composed of one part of Portland cement and seven parts of broken sand or gravel, with the proportion of sand to be determined by the government inspector. 30-ton blocks of cement concrete used cannot be put in place until 20 days old.

For the rock-work of the beds and body of the breakwater, the sea-wall and the Tepalcates dam, the contractor has been paid at the rate of $6.30 per metric ton. For the blocks of 30 tons or more in weight, employed for the protection of the crown and exterior slope above the berme of the breakwater as well as the blocks of cement concrete and mortar constituting the crown and upper mass the allowance is $11 each metric ton. For the smaller blocks destined to the interior slope of the breakwater as well as the slopes of the sea-wall, the price allowed has been $7.50 per metric ton. The Government may instruct the contractor to increase the proportions of cement determined in the specifications for the formation of the concrete, and if so will pay him for the increase at the price of $27.50 per ton.

The harbor thus created will afford safe and easy riding room to 100 sea-going vessels. To perfect the harbor and furnish later on the base for the system of wharfage to be voted by the Government, it was found necessary to carry a dike or sea-wall along the water-front of the town, a distance of about two kilometers. Behind the rock-work of the sea-wall the spaces are being gradually filled in with the materials dredged from the harbor and the backing of detritus from the quarries. A layer of detritus or broken stone covers the surface of the dredged material and a covering of stone, varying in size from 25 kilograms to three tons, and one meter thick, has been added over the dredged slope in front of the sea-wall, to prevent its displacement by the currents traversing the port or by those caused by the propeller wheels of steamers. This dike was constructed along the water-front of the town, to a

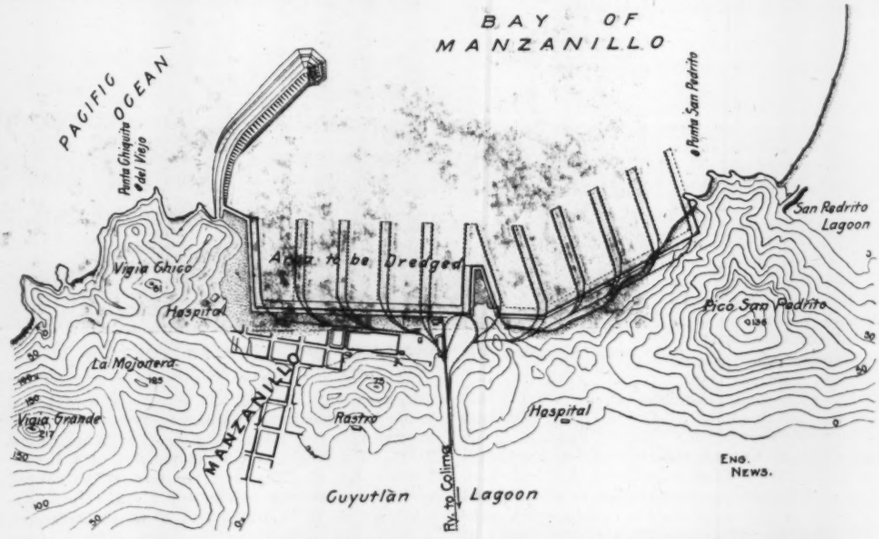


FIG. 2. MAP OF THE PORT OF MANZANILLO, SHOWING IMPROVEMENTS UNDER CONSTRUCTION AND PROPOSED.

height of three meters above mean tide, the outer or sea slope laid up at an angle 1 of vertical to 1 horizontal with selected blocks of stone. While the rock-work is of stones of random size, the exterior slope is covered carefully with granite blocks weighing from 3½ to 15 tons. The dredging has been done over the anchorage ground and the western part of the harbor to a depth of 8½ meters below mean tide.

Manzanillo is an old port. There Cortez outfitted his galleons to sail the Pacific. It is the sea-outlet of one of the smallest but richest states in the Mexican Union, the little State of Colima, with an area of 7,000 kilometers, or about the size of Delaware. The state has now a population of 100,000 merely, but so rich in agricultural output that the per capita of agricultural production is $30. When the harbor works are completed and the railroad connection opened inland to the City of Mexico, and as well to the rich States of Michoacan and Jalisco, the port of Manzanillo will waken from its sleep of centuries as Tampico and Vera Cruz have wakened. Col. Smoot is of the opinion that with adequate harbor accommodations at Manzanillo, which lies exactly west of the City of Mexico and is therefore its logical Pacific port, the agricultural industry in western Mexico will take on a great impulse, and that in a few years the agricultural exportations of all Mexico will exceed by at least one-hundredfold its mineral output, astonishing even as this is. In 1880 Mexico had only 500 miles of railroads; it has now 10,000 miles, with 1,500 locomotives and 20,000 cars. While the extraordinary sum of $767,151,842 foreign capital has been invested in Mexican railroads, most of it American money, Mexico has expended the sum of $151,251,093 in subventions to railroads.

FIG. 3. BIRD'S-EYE SKETCH OF MANZANILLO HARBOR WORKS AS THEY WILL APPEAR WHEN COMPLETED.

As for the ports of Mexico, it is not extravagant to say that Mexico has spent no less than $50,000,000, in placing in safe and practicable condition the half dozen harbors on the Gulf and the Pacific which so far constitute its harbor system. The port of Manzanillo lying as it does between Topolobampo and Salina Cruz, would have to the south the shortest rail and water route and on the north the shortest all-rail route possible between the United States Atlantic seaboard and its middle west, and the port of San Francisco. The line from Kansas City to Topolobampo is 1,000 miles shorter than from Kansas City to San Francisco. The route from New York to San Francisco via the Isthmus of Tehuantepec and Salina Cruz is 2,400 miles shorter than via Panama. In soon as trade is deflected to the Panama Canal, Manzanillo harbor will hold a position unique and unapproachable, for it will be the shortest and this wonderful open door that will be crowded as most direct rail route across Mexico, via the City of Mexico, and as a matter of fact is 700 miles nearer to the City of San Francisco than is the Isthmian port of Salina Cruz, in southern Mexico.

When Los Angeles builds its port at San Pedro, a port with a depth of 25 ft., and a wharfage of seven miles, slightly in excess of that of San Francisco, that will open to Mexico an American port 250 miles nearer than San Francisco. Freights from San Francisco which used to be $6 gold per ton to China and Japan, have been cut down already by the China Commercial Steamship Co., which takes Mexican merchandise to the Far East at $2.50 gold per ton. Steamers even now carry ores from the western coast of Mexico to Swansea, Wales, for $12 silver per ton.

As soon as the Panama Canal is open to the world's traffic, the ports of the Pacific will become important centers of commerce, and in the marvelous future which awaits Mexico, every railroad and every harbor must share proportionately, and none more than the splendid port now approaching completion at Manzanillo.

Manzanillo will have three markets to supply, those of Panama and its tributaries, the United States via California, and the Far East. In 1877 the Hawaiian exports were valued at $200,000, but last year the islands sent to San Francisco $30,000,000 worth of native products, not one of which cannot be produced in Mexico. Mexico, via Manzanillo, is far nearer the Californian ports than Hawaii can ever hope to be, and must supply the products now brought from far over the Pacific. Colima coffee already commands Mocha prices in San Francisco. Jalisco corn sells at first-class prices in California. The orange season in the section tributary to Manzanillo is midway between those of Florida and California. As soon as the untrodden west is threaded with a railroad or two to connect Mexican agricultural districts with the port of Manzanillo, that place now so quiet will become a mighty metropolis of international and intercontinental trade.

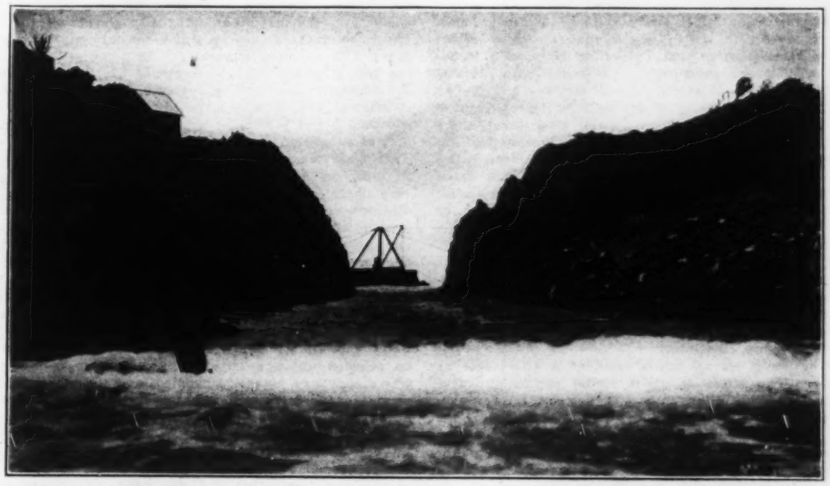


FIG. 5. THE VENTANAS CANAL, CUT THROUGH THE HILLS FOR THE INTRODUCTION OF SEA WATER INTO CUYUTLAN LAGOON, BACK OF MANZANILLO.

COST OF ELECTRIC RAILWAY POWER PRODUCTION AND TRANSMISSION IN THE STATE OF INDIANA.*

By A. S. Richey.†

It is wholly due to the development of the electric motor and electric power transmission that our interurban railways are enabled to run their trains in units of one, two or three cars each, at intervals of ten minutes or two hours as required and make stops as frequently as desired, and do it efficiently and economically. This is the fundamental reason for whatever success the interurban railways have achieved. As the method of conveying the energy from our coal pile to our car axles is the one thing which makes possible our business, and especially as the cost of this energy is one-fifth to one-quarter of our entire operating expense, it should be interesting to consider briefly the division of this cost into its components, together with a statement of the average costs per unit of the power used on the Indiana interurban roads.

We now have about 800 miles of interurban electric railways in the state, operating 100 cars regularly. These cars vary in size from the ordinary street car to the 60-ft. 35-ton car in use on the Indianapolis & Northwestern Ry. The average weight of the 100 cars in regular daily operation is 25.61 tons and their average scheduled speed is 20 miles per hour. The current for these cars is furnished by 24 power stations, the combined station capacity (exclusive of the Indianapolis Traction & Terminal Co.'s station) being slightly over 20,000 KW., or an installed capacity in generators of about 200 KW. for each interurban car operated and 25 KW. for each track mile operated. Half of the 24 power stations generate and deliver to the cars direct current, while the other 12 generate alternating current, distributing to the cars as direct current through 34 substations. The individual power station capacities vary from 200 to 6,000 KW. and comprise units of nearly every standard rating from 65 KW. to 1500 KW.

Assuming a power consumption of 100 watt-hours per ton mile, we have an average total at our 100 interurban cars of about 5000 KW., using the average figures as given above of 25.61 tons as the weight of car and 20 miles per hour as the schedule speed.

The average load factor of the power stations appears to be about 40% of the installed capacity. Therefore, the average output at power station bus-bars is over 8000 KW., which appears to indicate that the aggregate losses in overhead lines, rail return, substation apparatus, step-up transformers, etc., amount to more than 3000 KW. average, or an average efficiency from power station bus-bars to car motors of say 60%. As the assumption of 100 watt-hours per ton mile is probably high, this average efficiency of distribution, if in error, is to be considered higher rather than lower than the actual.

This loss of 40% of the total power generated must be divided between the stations generating direct current and those generating and transmitting alternating current and converting to direct current through rotary converters at substations. But 20% of the railway power generated in the state outside of Indianapolis is the output of direct current generators. Allowing 20% for the transmission losses from the direct current stations leaves us an efficiency of about 55% for the remaining 75% of the generated power which is the product of alternating cur-

*Abstract of a paper read at the first meeting of the Indiana Electric Railway Association, at Indianapolis.

†Chief Engineer, Indiana Union Traction Co., Anderson, Ind.

rent stations. This efficiency is probably made up about as follows:

Efficiency of step-up transformers	94%
Efficiency of transmission lines	97%
Efficiency of step-down transformers	93%
Efficiency of rotary converters	80%
Efficiency of direct current distribution	80%
Combined efficiency	54%

The figures given above as the efficiencies of transformers and rotary converters will, of course, not compare with the efficiencies guaranteed by manufacturers, as the guaranteed efficiencies are based on full load or nearly full load conditions, while the average load on rotary converter substations in the service which is most general in our roads is hardly greater than 25% of their rated capacities. This difference in distribution efficiency as between 80% for the average direct current station and 55% for the average alternating current station, is at first glance a surprising one and helps many a company to spend a large proportion of the dollars saved by an economical power station. Without doubt, there is more than one railway in the state, now operating an alternating current generating plant with transmission lines and substations, that could have invested the same money in direct current stations and trolley feeder and be operating to-day with a less charge to cost of power per car mile. On the other hand, there are several alternating current generating stations in the state which are delivering power to the car axles, after paying the price for the losses, at a cost much less than that at which they could accomplish the same result from direct current stations. The question of which system should be installed in a given case is one that should be carefully considered before a decision is made, as too often in the past few years has the alternat-current generating a plant with rotary converter substations been installed seemingly because such an outfit was in style, when the more simple system of direct current stations with plenty of trolley feed wire would have been more economical.

FIG. 6. 50-TON STEEL DERRICK FOR HANDLING HEAVY BLOCKS, ON BREAKWATER CONSTRUCTION.

For instance, let us briefly consider a given case as follows: Two cities of about 25,000 population each, situated 20 miles apart, each with a street railway system of say 10 city cars. These two systems are owned by a company which is to construct an interurban road connecting the two, the plans contemplating new power equipment. The schedule will call for two regularly operated interurban cars and 20 city cars, and an installation of say 1000 KW. capacity in power generating machinery. The location of an alternating current power station midway between the two towns with a substation at each end and rotaries in the power station will mean average transmission and conversion losses of about 45% of the total power generated. The location of a combination alternating-current and direct-current plant at one end with substations at the other end and midway will mean average transmission and conversion losses of about 35%.

With two direct-current stations, one at each end, and direct current feeder of double the cross section on the interurban line, the same results will be obtained with power losses of about 20%; the first cost of the installation will be no greater and the costs of generating the power will be but very little, if any, greater, provided, of course, that the facilities for obtaining coal and water are the same in the two towns. Assuming a generating cost of 10% more in the two small stations than in the one larger one (which is high), we have the cost of power at the car from the direct-current stations averaging about 25% lower than from the alternating-current stations at the middle location and over 10% lower than from a combined alternating and direct-current station at one end of the line, without considering the additional labor at substations which would be required with either of the alternating-current station.

If the given conditions be varied by the elimination of the city cars at one end of the line, leaving a load to be considered consisting of an interurban line of 20 miles in length, operating two regular cars on an hourly schedule, with a city system of 10 small cars centering at one end of the interurban line, then one direct current power station at or near the city car load probably will prove to be the most economical. In this case, of course, the trolley feeder must be increased greatly, and possibly a booster set will be required, but this additional investment will not reach the cost of transmission lines, substations and substation apparatus plus the capitalized cost of substation operation and losses.

However, when the proposed line is much to exceed 20 miles in length, especially if future extensions are very likely, and no great number of city cars are to be operated, economy begins to favor the alternating-current station with high tension transmission and substations, and as the length of line increases, and with it the number of cars to be operated and the total load on the station, it finally reaches a point where there is no question as between the one alternating-current station and a number of small direct-current plants. When the construction of a power plant of several thousand kilowatts capacity is under consideration, a location may be selected where a supply of good water is assured, where coal may be easily handled, and the many refinements conducive to economical operation may be introduced which are not possible or practicable in smaller stations. These points, together with the low cost per kilowatt-hour for labor which is possible with a large station, combine to reduce the initial cost of power to such a low figure that the seemingly low average efficiency of transmission and conversion, together with the costs of substation operation, may be met, and power still be delivered to cars many miles distant at a cost which will compare very favorably with direct current distribution within much smaller possible areas.

In this discussion, no mention has been made of the purely alternating current system, in which the car motors are designed for the use of alternating current, and for which the following claims are made: Reduction in first cost, by the elimination of the rotary converter and saving in trolley feeder; reduction in operating expenses by doing away with constant substation attendance; and increase in efficiency by the reduction of trolley and feeder losses, reduction or elimination of rheostatic car starting losses, and the complete elimination of rotary converter losses. As soon as the new alternating-current motor can demonstrate these points and prove to us that it is as well adapted to our purposes, as efficient, as reliable, and as easy of maintenance as the direct current series motor, we must seriously consider it in our future plans. The operation of cars by this system has just been started on the Rushville division of the Indianapolis & Cincinnati Traction Co., and the operation of this line will be very closely watched by street railway engineers and managers, until the success of the system has been fully demonstrated.

The replies which have been received to letters of inquiry represent 85% of the total installed generating capacity of the railway power stations of the state. These power stations generate an average of 5,845,450 kilowatt-hours per month at an average total cost of $44,156, or 0.755 ct. per kilowatt-hour. This average cost per kilowatt hour is divided as follows: Fuel, 0.526 ct.; labor, 0.158 ct.; lubricants, waste and miscellaneous supplies, 0.032 ct.; repairs, 0.039 ct.

The lowest cost per kilowatt hour reported is 0.505 ct., while the highest is 2.024 cts. The lowest cost of fuel is 0.368 ct.; the highest, 1.405 cts. The lowest cost of labor is 0.100 ct.; the highest, 0.331 ct. The lowest cost of lubricants, waste and miscellaneous supplies is 0.01[illegible] ct.; the highest, 0.086 ct. The lowest cost of repairs is 0.010 ct.; the highest, 0.218 ct. Deducting the output of the two most economical stations, representing two-thirds of the total output reported, the average cost of the balance of the power generated in the state is 1.021 cts. per kilowatt hour.

The figures which have been given are on cost of power at power station switchboards. As six of the 13 stations reporting are alternating-current stations with transmission lines and substations, these costs must be increased by the addition of substation operating expenses. With this addition, the total cost of power delivered to direct-current feeders is $47,500, or 0.964 ct. per kilowatt hour, the lowest cost reported being 0.747 and the highest, 2.024 cts.

The total amount of coal burned in all the stations reporting averages 532½ tons daily, 80% of which is Indiana run of mine and slack. The average cost of all coal burned is $1.89 per ton. The average consumption of coal is 5.56 lbs. per kilowatt hour, the highest consumption reported being 10.7 lbs. and the lowest being 4.9 lbs. per kilowatt hour. The power station capacity per interurban car operated averages, as has been stated, about 200 KW., the lowest being 150 KW. and the highest, 350 KW.

The roads reporting give a monthly car mileage of city cars of 1,122,060, and of interurban cars of 630,258 car miles. The average power consumption is 1.48 kilowatt-hours per car mile for city cars and 5.18 kilowatt-hours per car mile for interurban cars. On this basis, the average cost of power per car mile is 1.43 cts. for city cars and 5 cts. for interurban cars.

As illustrating the beneficial effect of the careful consideration of operating features in the engineering design and construction of a road, such as reducing curves and grades to the practical minimum, the careful location of substations with respect to their loads, and an economical distribution of copper, some figures on the Indianapolis Northern division of the Indiana Union Traction Co., as compared with the balance of that system, may be of interest. This division consists of the lines from Indianapolis to Logansport, Kokomo to Peru, and Tipton to Elwood. This portion of the line is fed from the power station at Anderson through 30,000-volt transmission lines to six substations, located 26, 42, 43, 59, 59 and 61 miles, respectively, from the power station, the average distance of all rotary converters being over 46 miles from the generators. The balance of the system is fed from the same power station through rotaries at the power station, and through 15,000-volt transmission lines to eight substations, the average distance of all rotary converters on these old divisions being but 15 miles from the power station.

The alternating-current output of the station is measured by an integrating wattmeter on the generator switchboard, while a second wattmeter measures the input to the step-up transformers supplying current to the transmission lines feeding to the Indianapolis Northern substations only. Notwithstanding the fact that 12% of the power used on the old divisions is delivered directly from the power station with no alternating current transformer or transmission losses whatever, and that the average distance from generator to rotary is 31 miles greater on the Indianapolis Northern divisions, the power station output to these new divisions is but 33% of the total, while handling 42% of the total car mileage. In other words, the power consumption per car mile, including all losses from generator to car motor, on the new lines is but two-third as much as on the old lines, even though the average transmission distance is three times as great. The class of cars in use on all divisions is the same, and the average schedule speed is slightly greater on the new lines than on the old.

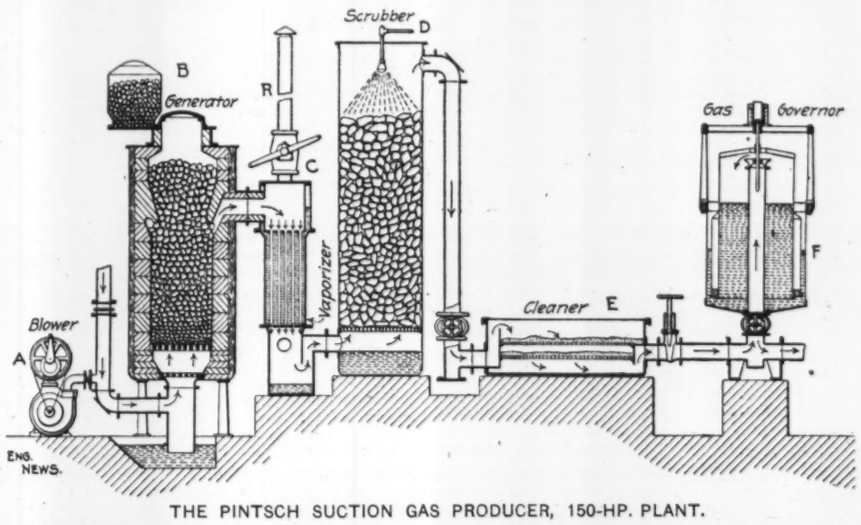
THE PINTSCH SUCTION GAS PRODUCER.*

By S. F. Saeger.

The development of the gas producer has brought out a new type of gas engine. Producer gas requires an engine with high compression, large inlet valves and governor control on the admission of both air and gas and the development of the gas producer industry was greatly retarded by the fact that these engine conditions were not met and met.

The idea of making the suction of the gas engine piston generate its own gas had been advanced, and was, in fact, patented by C. Wiegand in 1884, but after investigation on the part of several interested firms the scheme was dropped and the patents allowed to lapse. Wiegand was, however, close to the solution of the problem and failed only because of an incomplete understanding of the requisite conditions.

In the fall of 1900 the firm of Julius Pintsch, of Berlin, Germany, put upon the market a practical suction gas producer which overcame all of Wiegand's difficulties. This producer was simple in construction and operation, required little attention and gave a brake horse-power-hour in small units on one pound of Belgian anthracite. Four years practical experience with this plant brought many improvements and the construction of the present Pintsch suction gas plant is as follows: In the illustration, A, is a blower, furnishing draft for starting the fire and raising the heat in the generator to the proper temperature for the production of gas; B, a generator, equipped with a grate on which the coal is burned, a hopper, which allows charging during operation, a window valve for inspection of the fire and fire doors for poking down; C, is a vaporizer fitted with a small tubular boiler for the generation of steam and a relief pipe or chimney for use when the engine is not running; D, a scrubber consisting of a coke tower with a water spray for washing the gas; E, a cleaner containing wooden trays covered with wood shavings or saw-dust through which the gas is filtered giving up the last of its dirt and dust; F, a governor or pressure equalizer for maintaining a steady pressure throughout the apparatus.



THE PINTSCH SUCTION GAS PRODUCER, 150-HP. PLANT.

To operate the plant, a fire is lighted in the generator and a small amount of coal added, the blower being run until the fire is burning strongly with the relief valve R open. After 10 to 15 minutes blowing, the fire is sufficiently hot to give off gas; the relief valve is then closed and the gas allowed to pass through the apparatus, the blower being kept running at slower speed until the gas burns freely at a test cock beside the engine. The engine is then started, the blower stopped and the formation of gas becomes automatic; the suction stroke of the engine furnishing the draft through the fire. In ordinary practice, the fire is left burning over night with limited draft and only a few minutes blowing is required to brighten up the fire in the morning. The generator should be kept full of coal and the fire kept clean and bright. Since the apparatus is always under a slight vacuum, the fire doors can be opened at any time for cleaning out the fire.

The vaporizer is built in three sections, the upper being simply a chamber connected with the relief pipe or chimney, the middle, a small tubular boiler and the base section acting as a cleaning-pot and water seal when the engine is not running. By the passage of the hot gases coming from the generator through the flues of the boiler, the gas is cooled and steam is generated which is passed back under the grate for the purpose later described. The cleaning-pot or bottom section collects the heaviest dust and dirt coming over with the gas. By the admission of water to the cleaning-pot on shutting down, the rest of the apparatus is water sealed and the gas therein kept intact for starting up again.

The scrubber should never feel more than warm to the hand, otherwise steam will pass through it to the apparatus beyond, carrying with it a considerably greater percentage of dust, and the gas will not be cool when it reaches the engine. The gas must reach the engine cool or the charge taken in will be a charge of expanded and rarefied gas and will not carry sufficient energy.

In the cleaner the gas gives up the last of its dust and moisture and emerges cool, clean and dry.

The gas governor (a Pintsch patent) used on these plants is of great value. The engine, on its charging stroke, instead of drawing entirely from the producer draws its charge in part from the governor and the governor-spring then compensates this by drawing in a fresh charge from the producer. The resulting suction on the producer when the governor is used is a steady draught through the apparatus instead of the intermittent pull which is made by the suction stroke of the piston. This steady suction gives a steady even draught through the fire, which is an essential condition for the continuous formation of gas of a uniform quality, and as shown by actual test gives an added economy of 10%. Another great benefit derived from the governor is the ability to run any number of engines from a single producer with certainty of operation and without any loss in economy, it being only necessary to attach a governor to the individual gas main leading to each engine.

The theory of the formation of the gas is that, by limiting the amount of air admitted to the fire, complete combustion of the coal is not permitted and the supply of oxygen being insufficient, carbon monoxide, CO, is formed instead of carbon dioxide, CO_2, while the steam formed in the vaporizer is led back under the grate and breaks up on striking the incandescent fuel, giving free hydrogen and carbon monoxide, the carbon monoxide and the hydrogen forming the power gas for the engine. The average gas with a good grade of anthracite should have a heat value of 130 to 140 B. T. U. per cu. ft. and the constituents by volume should be as follows:

Carbon dioxide, CO_2	6%
Carbon, monoxide, CO	24%
Hydrogen, H	15%
Nitrogen, N	55%
Hydro carbon, CH_4	trace
Oxygen, O	trace

Should the apparatus be of faulty design and more steam be admitted than the fire can break up, the effect will be a deadening of the fire and the diminution of the gas formed and in the end a complete shutting down. On the other hand, if an insufficient amount of steam is provided, the grates will burn out rapidly and the gas through a lack of hydrogen will be lacking in power. When anthracite is used the amount of water transformed should be from 0.8 to 1.2 times the weight of the coal burned.

The cleaner is often left off in the cheaper forms of apparatus but an examination of the pipes on such a plant after a month's use will conclusively prove its necessity. Where water is an important factor the scrubber may be run hot and less water used, but it will be done at the expense of the cleaner which will be forced to remove a greater percentage of dust, the same having been carried through to it by the non-condensed vapor, the sawdust and shavings would therefore require more frequent cleaning and renewal. Wherever necessary a cooling system can be installed and the water re-used after slight filtration.

As an example of the efficiency with which the gas in this apparatus is cleaned and dried an instance may be cited of an installation of Julius Pintsch at Heusy in Belgium, where a plant was run for an entire year without any cleaning whatsoever of either the engine or gas apparatus and the deposit of foreign matter found in the same at the end of the year was inappreciable. As for its reliability a Pintsch producer and 50 HP. Deutz engine was, in one instance, through necessity, run continuously night and day for nine months without a single stop for any cause whatsoever.

The superiority of the suction system over the old pressure type of gas producers has been conclusively demonstrated. There were originally many objections raised to the suction type and the idea of having the engine draw in its charge of gas, thereby making the draught for the fire and rendering the apparatus automatic, was considered impracticable. The point was raised that the gas being at less than atmospheric pressure would interfere with the satisfactory working of the engine. If it were impossible to regulate the admission of the air with the pressure of the gas this objection would hold true, but the same is taken care of by providing a separate air inlet on the engine which allows the formation of a suitable mixture in all cases.

The suction gas plant is simpler, cheaper and requires less room than the pressure plants. It is more economical of fuel and requires less attention. It requires no separate steam boilers and there is no steam under pressure. It requires no large gas holders and there is no chance for gas to escape into any of the rooms of the building as the whole apparatus is always under slightly less than atmospehric pressure and any leakage would be a leakage of air into the apparatus and not of gas out. A leakage sufficient to bring about a stoppage would have to be very large and could not occur in regular working except through some extraordinary accident.

The working of the Pintsch plant is practically automatic and the fire can be poked down and clinkers and ashes removed without causing any interruption to the production of the gas.

The air entering the producer below the grate is piped from outside the building so that any gas which might collect due to a sudden stoppage of the engine or a clogging of the pipes must escape through this inlet pipe to the outer air. Any irregularity is at once traceable by a series of gages which show the amount of vacuum at all times in the various parts of the installation.

It is a scientifically designed plant, thoroughly worked out and certain of operation, requires comparatively little room and is of such a character as to be a perfectly safe installation in office buildings, hotels and the like, for which work it is in fact in wide use abroad, where Julius Pintsch has already installed over 2,000 plants ranging from 4 to 2,000 B. HP.

Julius Pintsch has built producers in single units up to 2,000 HP. on the same lines as the smaller plants. These plants are operating with perfect success and consume only about ¾-lb. of coal per B. HP. per hour, the consumption decreasing with the increasing size of the unit. While this type of apparatus here illustrated has been spoken of as only available for anthracite coal it is with slight alterations equally available for any fuel that has not a tar base.

The consumption with gas coke, clean gas coke being advisable because of its freedom from sulphur, is in the 50-HP. size 1.07 lbs. per B. HP. per hour, and about the same with charcoal. With pea anthracite at $5 a ton, the fuel cost is ¼ ct. per B. HP. per hour.

To date, the use of bituminous coal is confined to large units. To successfully operate a gas engine the tar must be removed, which necessitates either an elaborate system of scrubbers and cleaners, or the combustion of the tar in the producer itself. Working on the latter principle Julius Pintsch now has in operation plants for both lignite and bituminous coal, and a plant of 400-B. HP. is working admirably on bituminous coal with the very low consumption of 0.625 lb. per B. HP. per hour. With bituminous coal at $3 a ton this brings the cost per B. HP. per hour down to less than 0.1 ct., which, barring water power and natural gas, may be said to be the cheapest form of power yet known.

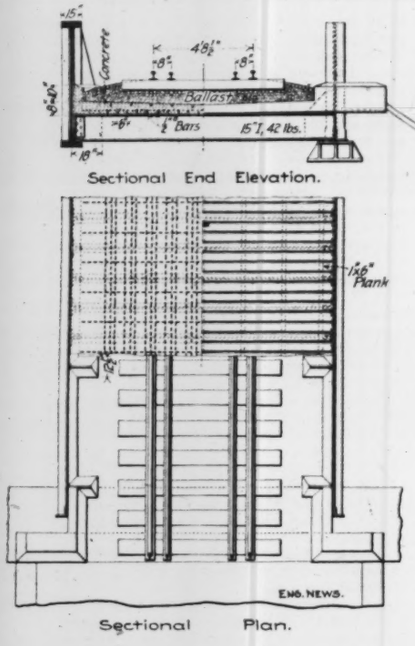
These plants are manufactured by the American Suction Gas Producer Co., of Lansing, Mich.

*Abstract of a paper read before the Michigan Engineering Society.

CONCRETE FLOORS FOR RAILWAY BRIDGES.

A new development in solid floor construction for steel railway bridges is the use of reinforced concrete, either in the form of a continuous monolithic slab built in place, or a series of separate slabs which can be set in place at any time. In a paper on solid floors for railway bridges recently presented before the Western Society of Engineers, Mr. A. F. Robinson, M. Am. Soc. C. E., Bridge Engineer of the Atchison, Topeka & Santa Fe Ry., referred to this class of construction as the coming type of solid floor. We illustrate herewith some examples of solid floors of reinforced concrete, as used by different railways.

Figs. 1 to 6 show standard designs of the Wabash Ry., for drawings of which we are indebted to Mr. A. O. Cunningham, M. Am. Soc. C. E.,



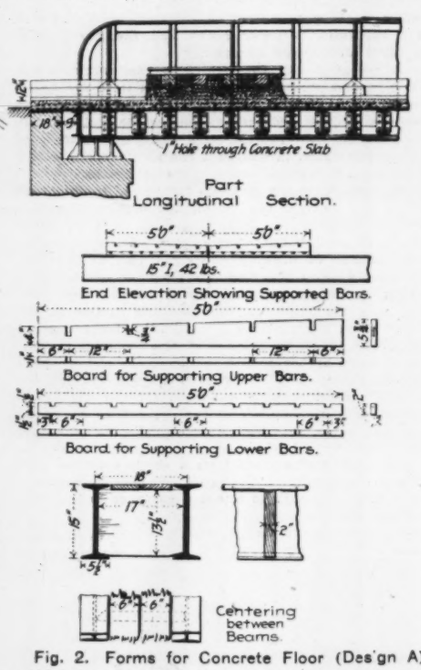

1" Hole through Concrete Slab
Part Longitudinal Section.
15"I, 42 lbs.
End Elevation Showing Supported Bars.
Board for Supporting Upper Bars.
Board for Supporting Lower Bars.
Centering between Beams.

Fig. 2. Forms for Concrete Floor (Design A).

FIG. 1. STANDARD REINFORCED CONCRETE FLOOR FOR THROUGH GIRDER BRIDGES (DESIGN A); WABASH RY.

W. S. Newhall, Chief Engineer; A. O. Cunningham, M. Am. Soc. C. E., Bridge Engineer.

Bridge Engineer of that road, who states that this class of construction has been used for more than a year and has been found both satisfactory and economical. The floor in "Design A," Fig. 1, is for through bridges and consists of a 6-in. flat slab of reinforced concrete on 15-in. I-beams, 18 ins. apart. It will be seen that the sides are carried up to form curb walls against the girders and enclosing the gusset plates. Fig. 2 shows the construction of the forms, which consist simply of 6-in. planks flush with the tops of the floor beams and supported by cross pieces between the beams. When the concrete has set, these cross pieces are knocked out, allowing the planks to fall away from the floor. This cut also shows the forms which hold the reinforcing bars in position while the concrete is being deposited.

In "Design C" (also for through bridges), Fig. 3, the slab is at the bottom of the floor beams, enclosing the lower flanges, while concrete ribs enclose the upper part of the beams, forming troughs which are filled with the ballast. The floor beams are 15-in. I-beams, 20 ins. c. to c. A transverse rod is laid in the bottom of each trough, while short pieces of longitudinal rods are placed between the webs of the I-beams. The ballast is retained by curb walls, as in the other design. In "Design B" the construction is very similar, but with modifications in detail. Fig. 4 shows the construction of the forms.

The floor in "Design D," Fig. 5, is of the flat-slab type, for deck bridges, and has a total width of 14 ft. over the parapet or curb walls. The forms used are similar to those shown in Fig. 2.

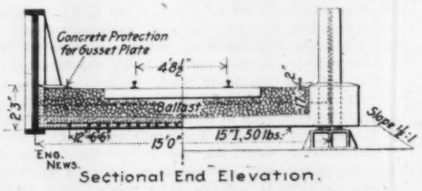
Fig. 6 shows a bridge built of old bridge stringers embedded in concrete beams and carrying a floor of concrete, all reinforced by longitudinal and transverse rods. The floor extends over the parapet or end wall of the bridge abutment, and the top of this wall is well coated with soap, so that there will be no adhesion of the floor, which is thus free to slide on the abutment with the contraction and expansion of the bridge.

A floor similar to that of "Design A," Fig. 1, but somewhat lighter in section, has been used by Mr. E. H. Lee, Chief Engineer of the Chicago & Western Indiana Ry., for the 70th St. bridge on the joint track elevation of Chicago. Here the concrete is carried up to a narrow width against the web plate, and is coated with a waterproof composition. Similar floors have been built by the Chicago & Eastern Illinois Ry. at Danville, Ill., and by the Wheeling & Lake Erie Ry. at Valley Junction, O. The floor of this last bridge was put in while the bridge carried traffic. The floors for the through girder bridge in "Design A," Fig. 1, and for the deck-girder bridge, Fig. 6, have longitudinal rods in the bottom and top of the slab. This is for the reason that the slab is considered a continuous girder on several supports. The bottom of the slab is reinforced with more rods than the top because it has in addition to take care of the stretch in the bottom of the slab due to the deflection of the girders. The cross rods in the bottom take care of the deflections in the slab due to the deflection in the I-beams.

The quantities of concrete and concrete materials required for these floors are shown in the accompanying table. The rock concrete is composed of 1 part of cement, 2 parts of sand, and 4 parts of stone small enough to pass through a ring 1 in. in diameter. The mortar concrete is composed of 1 part of cement and 3 parts of coarse sand. All the reinforcement consists of ½-in. steel bars.

Table of Quantities in Concrete Bridge Floors: Wabash Ry.

Length of girder, ft.	Rock Concrete. Cement, bbls.	Sand, cu.yds.	Stone, cu.yds.	Concrete, cu.yds.	Mortar Concrete. Cement, bbls.	Sand, cu.yds.	Concrete, cu.yds.
Design A: Through Bridges (Fig. 1).							
30	18	6	12	12	22	11	11
50	27	9	18	18	36	18	18
75	39	13	26	26	52	26	26
100	51	17	34	34	68	34	34
Design C: Through Bridges (Fig. 3).							
30	29	10	19	19	38	19	19
50	44	15	29	29	58	29	29
75	65	22	43	43	86	43	43
100	84	28	56	56	112	56	56
Design D: Deck Bridges (Fig. 5).							
30	21	7	14	14	28	14	15
50	33	11	22	22	44	22	22
75	47	16	31	31	62	31	31
100	62	21	41	41	82	41	41



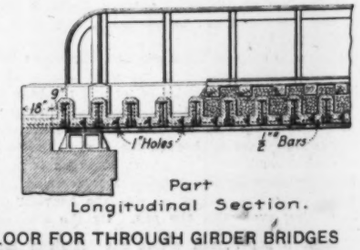


FIG. 3. STANDARD REINFORCED CONCRETE FLOOR FOR THROUGH GIRDER BRIDGES (DESIGN C); WABASH RY.

In Fig. 7 is shown the floor of a double-track four-span plate girder deck bridge carrying the new Chicago and St. Louis line of the Chicago & Eastern Illinois Ry. over the Embarras River at Villa Grove, Ill. This was designed by Mr. T. L. Condron, M. Am. Soc. C. E., of Chicago, and consists of a monolithic concrete slab floor for each track, reinforced by longitudinal and transverse bars, and having a curb wall along the outside to retain the ballast. The original plan was to have the floor composed of slabs 6 x 14 ft., which could be built elsewhere and put in place on the girders after completion.

In Fig. 8 is shown the cross section of a concrete slab floor used by the Chicago, Burlington & Quincy Ry. for deck bridges. Mr. C. H. Cartlidge, M. Am. Soc. C. E., Bridge Engineer, states that this is in use on two double-track bridges and one single-track bridge, while plans have been made for four more bridges. In the double-track floor the concrete is put in for each track separately, leaving one track open for traffic, the two slabs being united by the transverse rods. In this floor no longitudinal rods are used. The concrete is composed of 1 part of cement, 2 parts of sand and 4 parts of ½-in. stone.

GRANULATED SLAG FOR BALLASTED BRIDGE FLOORS.*

By E. K. Morse,† M. Am. Soc. C. E.

Many of our bridge engineers have never ridden on a fast express locomotive drawing a heavy train over a bridge. It is only in studies of this kind that one can fully realize the importance of adopting that design which will give to the engine and train an easy elastic roadbed on the modern railroad bridge the same as in the main line. The style of floor commonly adopted on our railroad bridges, the open-floor system, consists of wooden guards notched and bolted to the ties, which are in turn bolted to the steel stringers; the ties support the rails directly over the stringers, and all combine to make a solid roadbed, entirely the reverse of the conditions on the main line, where the ties give sufficiently under engines and train load to form an elastic bed. The effect of an engine coming upon such a bridge from the ground-supported track is in the nature of a blow. The only provision made for this effect up to date is additional weight and rivets in the floor system.

Some five years ago I began using granulated cinder, made from blast furnace slag, for extensive fills at the Eliza furnaces of the Jones & Laughlin Steel Company. I soon discovered qualities in it that led me to use it some years ago on the same company's hot metal bridge and the Monongahela Connecting R. R. bridges across the Monongahela river. In these bridges the floor was covered over with ⅜-in. plates, built in the shape of a trough, and filled to the depth of 12 ins. with granulated cinder, on which the track was laid with ordinary ties, etc., same as the yard track. The result has been a soft elastic track on the bridge, which rides even smoother than on the ground, and is easier kept in repair. A wreck or derailment simply bunches up the ties and has thus far not produced the slightest damage to the structure, though there have been some nasty wrecks. The bridge is used for yard switching and subject to constant loading of 100 tons of ore and pig metal, exclusive of the weight of the cars. This cinder is perfectly clean, keeps dry, is a paint and wood preservative, weighs about 15 lbs. per cu. ft. when first made and dry, packs to about 35 lbs. and when the ties are once imbedded it does not settle afterwards.

There has been an animated discussion of late in New York in the scientific papers as how best to deaden the sound in elevated railroad and railway bridges. My suggestion would be to build a trough on the stringers, fill it up with granulated furnace cinder, lay down the ordinary ties and spike the rails the same as any surface track and the cheapest and best cushioned roadbed that has yet been discovered will be the result.

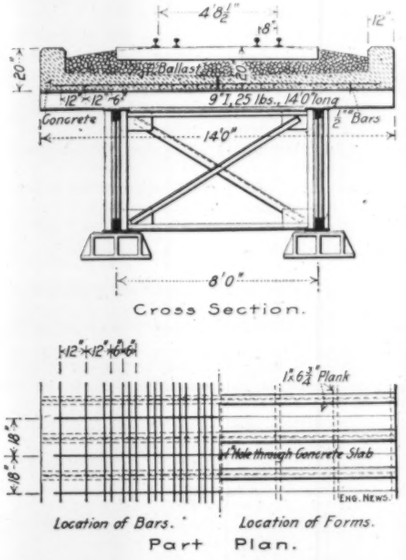
*Abstracted from a paper read before the Engineers' Society of Western Pennsylvania, January, 1905.

†Farmers' National Bank Bldg., Pittsburg, Pa.

THE EFFICIENCY OF WASTE GAS BOILERS IN CONNECTION WITH ROTARY CEMENT KILNS.

By A. B. Helbig.*

It is well known to everyone connected with a cement mill that the fuel bill is one of the largest items of cost in the manufacture of Portland cement. Efforts to reduce this item have naturally increased as the market price of cement has decreased. So far, two methods have been suggested for reducing the amount of fuel consumed per barrel of cement manufactured. One is to increase the length of the rotary kilns and the other is to utilize the heat of the waste gases to generate steam for power. Lengthening of the kiln is certain to increase the output up to a certain ratio between the diameter of the kiln and its length, and it is usually only a question of cost and very often also of room in the old mills whether or not the kilns shall be lengthened. I do not believe that new kilns shorter than 100 ft. will be installed in the future. Thermally, however, a 60-ft. kiln, with a waste gas boiler, is just as efficient as any longer kiln, and the object of this paper is to prove that the waste gas boiler alone solves conclusively the fuel problem of the cement mill.



The solution of the problem of utilizing waste gas boilers is by no means easy, and I am entirely of the opinion of Mr. Spackman that the pioneer in the attempt will have his troubles at the start. His consolation will be the knowledge that his neighbor will have quite as much trouble in adapting the same outfit to his own local conditions. The rotary kiln in combination with a waste gas boiler is a very complicated machine. To put a certain size boiler in a certain way behind a certain size kiln may be a success, but it will be the most economical and best outfit only for that individual mill under its special conditions. How much results vary in mills which have apparently the same conditions of raw material, coal and machinery is well known. If, however, the following investigations have been thoroughly made, the installation of waste gas boilers in a cement plant, if rightly done, should reduce the fuel bill from 50 to 60%.

The specific heats and other data used in the following calculations may be subject to change in the future, but these changes should not be great enough to alter materially the conclusions. For the succeeding calculations the following data are therefore assumed to be correct:

(1) 270 kilograms of raw material make 172.5 kilograms of clinker or one barrel of cement. (These figures are rather high but are exact enough.)

(2) The raw material contains 0.5% H_2O and 0.4% SO_3.

*Vice-President and Superintendent, German-American Portland Cement Works, La Salle, Ill.

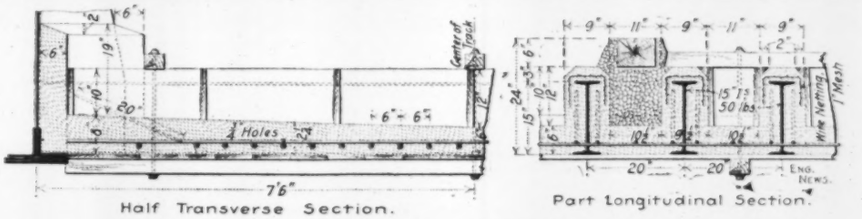


FIG. 4. FORMS FOR CONCRETE FLOOR (DESIGN B).

(3) The cement analyses 62% Ca O = 106.95 kilograms per barrel, and 2.8% Mg O = 4.83 kilograms per barrel.

(4) The clinkers with 0.246 specific heat leaves the kiln at 1,000° C and 0.9 of this heat can be utilized to heat the air of combustion.

(5) The specific heat of the air is assumed as constant = 0.2375. (Stevens, "Annalen der Physik," 1902, has proven that the specific heat of air increases with the temperature.)

(6) The burning of the coal is performed first, with the theoretical air supply, and, second, with 1.3 of the theoretical air supply.

(7) All the combustible matter of the fuel burns, therefore the efficiency of the fire-box N = 1.

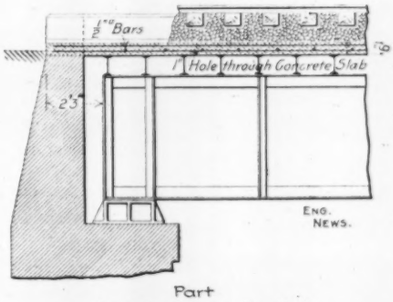


FIG. 5. STANDARD REINFORCED CONCRETE FLOOR FOR DECK GIRDER BRIDGES (DESIGN D); WABASH RY.

(8) One-tenth of the heat is lost by radiation in front of the kiln. The coefficient of radiation according to Peclet, is then d = 0.1. The temperature of the flume T is then,

T (L + 1) C = N W (1 — d) + L t 0.2375, in which

W = calories per kilogram of fuel.
L = kilograms of air per kilogram of fuel.
C = 0.24, specific heat of combustion gases.
N = 1.
d = 0.1.
t = temperature of air entering kiln.

Solving the equation for T, we have

$$T = 3.75 \frac{W}{L+1} + \frac{t\,L}{L+1}$$ when the factor $\frac{0.2375}{0.24}$ is made equal to unity.

(9) The loss by radiation and conduction of the kiln shell is 17,000 calories per barrel. This amount has been figured by the formula of "The Huette," 1902, p. 294, and will vary greatly with the output of the kiln, the thickness of the lining, and the coefficient of conduction of the lining and the kiln shell. The total loss W in calories per square meter of area is

W = 125 s (1.0077 f_1 — (1.0077 f_2) + 055 b (t_1 + t_2)

S = coefficient of radiation of rusty iron = 3.36.
t_1 = temperature of kiln shell.
t_2 = temperature of air.
b = 6 = coefficient of construction.

The heat of combination according to Berthelot "Thermochemie," Vol. II., is:

Ca O,	106.95 kg. × 530 =	56,684	calories.
Mg O,	4.83 kg. × 827 =	3,994	"
Total		60,578	"

Based on these data the heat used per barrel of cement may be summarized as follows:

	Calories.	Calories.
(1) For radiation and conduction of kiln shell		17,000
(2) Loss due to clinker heat 0.1 × 1,000 × 170 × 0.246		4,182
(3) Heat lost in evaporation of water 270 × 0.005 × 600		810
(4) Heat used in decomposition of sulphuric anhydrid 270 × 0.004 × 1,050		1,134
(5) Heat used in expulsion of CO_2:		
106.95 (44 ÷ 56) × 900	84,942	
4.83 (44 ÷ 40) × 407	2,161	
(6) Loss due to flue dust (estimated)	3,562	
Total		113,791
Loss heat of combination		60,678
To burn one barrel of cement		53,113

All of the calculations are made for a temperature of zero centigrade. The raw material at 20°C will then bring into the kiln, 270 × 0.22 × 20 = 1,198 calories.

Therefore, the total heat units necessary to burn one barrel of the cement in question with

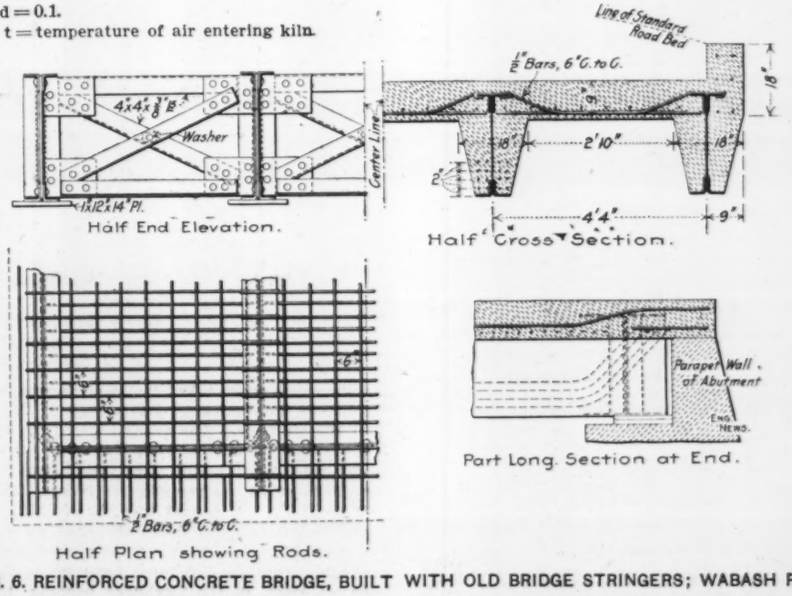

Line of Standard Road Bed
Half End Elevation.
Half Cross Section.
Half Plan showing Rods.
Part Long. Section at End.
Parapet Wall of Abutment

FIG. 6. REINFORCED CONCRETE BRIDGE, BUILT WITH OLD BRIDGE STRINGERS; WABASH RY.

waste gases at 0°C. will be 53,115 — 1,188 = 51,925 calories.

The following three kinds of coal have been taken under consideration:

	B. T. U.	Calories.
Pittsburg bituminous	13,410	= 7,450
Hocking Valley	12,130	= 6,740
Mt. Olive, Illinois	10,490	= 6,830

These coals analyze as follows, according to "Steam 1902," Babcock & Wilcox:

	H_2O	C	H	O	S	N	Ash.
Pittsburg	1.4	75	.5	8	1.6	.1	8
Hocking Valley	7.5	67	4.8	10	1.5	1.2	8
Illinois	11	55	.5	11	.3	.1	13

Neglecting the oxygen necessary to burn the volatile sulphur in the coal and assuming that the coal has been dried to 5% moisture, a kilogram of coal requires then the following amounts in kilograms of oxygen:

	Pittsburg.	Hocking Valley.	Illinois.
For the hydrogen: $H = \frac{0}{8}$	0.04 × 8 = 0.32	0.035 × 8 = 0.28	0.03 × 8 = 0.24
For the carbon	0.77 × 32/12 = 2.05	0.67 × 32/12 = 1.80	0.56 × 32/12 = 1.49
Total	2.37	2.08	1.73

The air contains generally 20.5% of oxygen and 78.7% of nitrogen, with a remainder of water and carbon dioxide. A cubic meter of air contains: 0.205 × 1.4298 = 0.293 kg. of oxygen. To burn one kilogram of coal with theoretical air supply requires then the following amounts of oxygen:

Pittsburg coal, 8.00 cu. cm.
Hocking Valley coal, 7.10 cu. cm.
Illinois coal, 5.90 cu. cm.

With a specific gravity of 1,288 these amounts become:

Pittsburg coal, 10.42 kilograms.
Hocking Valley coal, 9.14 kilograms.
Illinois coal, 7.60 kilograms.

With 1.3 of the theoretical air supply the amounts become:

Pittsburg coal, 13.55 kilograms.
Hocking Valley coal, 11.88 kilograms.
Illinois coal, 9.88 kilograms.

The air of combustion brings to the process at 20°C., with theoretical air supply, for each kilogram of coal:

Pittsburg coal = 10.42 × 0.2375 × 20 = 49.5 calories.
Hocking Valley coal, = 9.23 × 0.2375 × 20 = 43.8 calories.
Illinois coal, = 7.60 × 0.2375 × 20 = 36.1 calories.

With 1.3 of theoretical air supply the figures are:

Pittsburg coal, 64 calories.
Hocking Valley coal, 57 calories.
Illinois coal, 47 calories.

To burn one barrel of cement requires

$$\frac{250{,}000}{7{,}450} = 33.6 \text{ kgs. Pittsburg coal.}$$

$$\frac{250{,}000}{6{,}740} = 37.1 \text{ kgs. Hocking Valley coal.}$$

$$\frac{250{,}000}{5{,}830.} = 42.9 \text{ kgs. Illinois coal.}$$

To raise the temperature of the air of combustion 1°C., we have to use with theoretical air supply:

33.6 × 10.42 × 0.2375 = 83.15 Pittsburg coal.
37.1 × 9.14 × 0.2375 = 80.53 Hocking Valley coal.
42.9 × 7.60 × 0.2375 = 77.43 Illinois coal.

With 1.3 theoretical air supply the corresponding figures are:

Pittsburg coal	108.09
Hocking Valley coal	104.7
Illinois coal	100.7

The 381.96 calories regained from the clinker heat, will bring the air to the following temperatures:

	P.	H. V.	I.
Theoretical air supply	458	474	494
1/3 " " "	353	365	384

If we were to build around the kiln a revolving or stationary shell and draw the air of combustion through this annular space, we should be able to regain about 80% of the heat lost by radiation and conduction, and this would raise the temperature of the air to:

	Pitts.	H. Val.	Ill.
Theoretical air supply	621	643	670
1/3 " " "	478	495	515

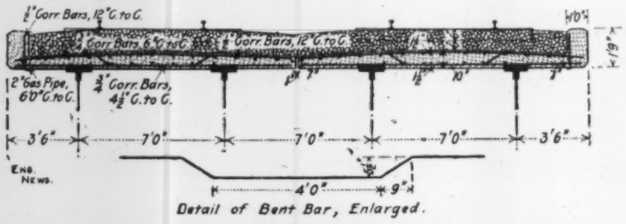


FIG. 7. BRIDGE FLOOR OF REINFORCED CONCRETE; CHICAGO & EASTERN ILLINOIS RY.

W. S. Dawley, Engineer Maintenance of Way;
T. L. Condron, M. Am. Soc. C. E., Designer.

From this we can figure the temperature of the clinkering zone and have then with no heating of the air t = 0°.

	Pitts.	H. Val.	Ill.
Theoretical air supply	2,448°	2,502°	2,542°
1.3 " " "	1,920°	2,010°	2,094°

Using the clinker heat:

	Pitts.	H. Val.	Ill.
Theoretical air supply	2,863°	2,929°	2,979°
1.3 " " "	2,248°	2,346°	2,439°

Using clinker heat and heat of kiln shell:

	Pitts.	H. Val.	Ill.
Theoretical air supply	3,014°	3,081°	3,134°
1.3 " " "	2,365°	2,466°	2,561°

The burning temperature of the cement in question lies, in my opinion, between 1,300° and 1,400°, and I do not believe that cement can be burned with a coal flame as low as 1,000°, as stated by Mr. Jos. W. Richards in his paper on "The Thermal Efficiency of a Rotary Kiln." As the temperature was taken in the chimney 4 ft. from the upper end of the kiln, the gases of the gas analysis if taken at the same spot might have been mixed with air which did not go through the kiln. To determine this I have had tests made from waste gases taken inside of the kiln about 1 ft. from the discharge end and about 12 ft. high in the chimney. The gases taken from the first place analyze CO_2 = 21.7; CO = 0.3; O = 1.3%. The gases taken at the same time 12 ins. inside of a 48-in. stack analyze, CO_2 = 10.6%; CO = 0%; O = 11.5%. A second test showed, (1) CO_2 = 18.2%; CO = 1.6%; O = 1.6%; (2) CO_2 = 10.5%; CO = 0%; O = 9.6%. The gases for analysis should, therefore, be taken from inside the kiln, or, at least, in the discharge opening, to avoid any chance of their becoming mixed with gases which have not passed through the kiln.

The equation $T(L + 1)\,0.24 = N\,W\,(1 - d) + L\,t\,0.2375$ can be used to find the heat lost by radiation in front of the kiln, which will certainly vary with different kiln arrangements and with the same kiln in different mills. After determining the temperature T at the clinkering zone by optical pyrometer and calculating from the results of the gas analysis; (1) the amount of air in kilograms to burn 1 kg. of fuel, and, (2) the efficiency of the furnace, the coefficient of radiation is then,

$$d = \frac{L\,t\,0.2375 + N\,W - T\,(L+1)\,0.24}{N\,W}.$$

In this equation everything has been figured out with the exception of N. To find N, the fuel used to burn the cement has to be analyzed very thoroughly the percentages of carbon, hydrogen, oxygen, volatile sulphur, and nitrogen have to be found. The amount of carbonic acid per barrel and the kilograms of fuel per barrel have to be found. Finally, analyses of the waste gases should be made as often as possible. The above task involves a great many very delicate operations, but it is the only way of determining the necessary fineness to which the coal should be ground. It is possible that a great portion of the carbon passes through the kiln without burning even though the chimney gases are white. If the chimney of the kiln sparks in the night time, it is a sure sign that the coal is not ground fine enough. The moisture of the air during the test should be determined, and also the oxygen, but the traces of CO_2 may be neglected.

An example will serve to illustrate the way of getting the coefficient N and in the end the absolute fineness necessary for the coal. We have found the air to contain 78.7% N and 20.5% O, and the coal, 60% C, 4% $H - \frac{0}{8}$, 1% volatile sulphur, and 1% nitrogen, and we use 50 kgs. of this coal to burn one barrel of cement, which liberates 90.9 kgs. CO_2. A kilogram of coal has 6,000 calories. The waste gases analyze, 22% CO_2, 0% CO and 5% O. We have then per barrel y cubic meters of waste gases, and as there are 0.22 × 0.54 = 0.1188 kgs. C per cubic centimeter

$$y = \frac{0.60 \times 50 + 90.9 \times \frac{12}{44}}{0.1188} = \frac{54.8}{0.1188} = 462$$

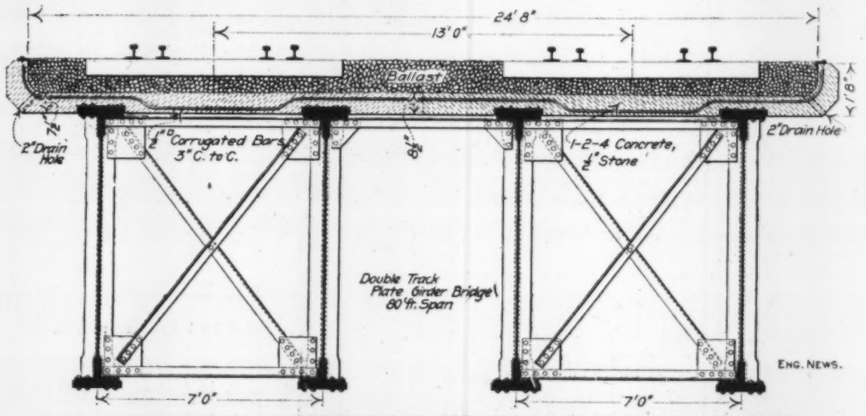


FIG. 8. REINFORCED CONCRETE FLOOR FOR DECK GIRDER BRIDGES; CHICAGO, BURLINGTON & QUINCY RY.

C. H. Cartlidge, M. Am. Soc. C. E., Bridge Engineer.

cubic meters of every particle of coal were burned.

Assuming that the hydrogen, oxygen and sulphur are completely burned, it requires for

$$H - \frac{0}{8} = 0.04 \times 50 \times 8 = 16 \text{ kgs. O, and for}$$

$$S = 0.01 \times 50 \times \frac{32}{32} = 0.5 \text{ kgs. O.}$$

16 kgs. + 0.5 kgs. = 16.5 kgs.

The nitrogen of the coal, which is about 0.4 cubic meter, may be neglected without altering the result materially. We have then y cubic meters of waste gases and in them $0.75 \times y$ cubic meters of nitrogen which equal $0.73 \times \frac{20.3}{78.7} \times y$ cubic meters of oxygen. In the waste gases there remained $0.05 \times y$ cubic meters of oxygen unchanged. Therefore, $0.14 \times y$ cubic meters of oxygen have been used to burn the carbon of the coal. The total CO_2 of the waste gases are $0.22 \times y$ cubic meters $= 0.22 \times y \times 1.9774$ kgs., which correspond to $0.22 \times 1.9774 \times \frac{32}{44}$ kgs. oxygen, but from this total $90.9 \times \frac{32}{44} = 66.1$ kgs. oxygen come from the raw mixture. We get then the equation:

$$y \times 0.22 \times 1.9774 \times \frac{32}{44} - 66.1 = y \times 0.14 \times 1.4298 - 16.5.$$

$$y \times (0.22 \times 1.9774 \times \frac{8}{11} - 0.14 \times 1.4298) = 49.6.$$

$y\ (0.3164 - 0.2002) = 49.6.$
$y \times 0.1162 = 49.6.$
$y = 427$ cubic meters.

To find the carbon lost we have then the equation:

$$\frac{50\ (0.60 - x) + 90.9 \times \frac{12}{44}}{0.1188} = 427$$

$$30 - 50x + 24.8 = 427 \times 0.1188$$
$$50x = 54.8 - 50.73 = 4.07$$
$$x = 0.081 = 8.1\%$$

There is a very interesting connection between this figure and the residue on a certain size screen with Illinois coal under special draft conditions. The coefficient of the furnace is then

$$N = \frac{6{,}000 - 9{,}081 \times 8080}{6{,}000} = 0.891 = 0.891.$$

With coal fine enough N = 1, but there is of course a limit in coal grinding and only practical tests will determine what is the most economical fineness of the coal taking its price and the cost of grinding into consideration. I believe that the determination of N will give some surprises to managers of cement mills.

It has been assumed in the preceding discussion that we burn a barrel of cement first with theoretical air supply, and second with 1.3 theoretical air supply. In the first case there is no oxygen in the waste gases. In the second case we have for,

Pittsburg coal, 33.7 × 0.3 × 2.37 = 23.96 kgs. = 16.8 cu. m. O.
Hocking Valley coal, 37.1 × 0.3 × 2.08 = 23.15 kgs. = 16.2 cu. m. O.
Illinois coal, 42.9 × 0.3 × 1.73 = 22.26 kgc. = 15.6 cu. m. MO.

The cubic meters of nitrogen in the waste gases are, with 1.3 of the theoretical air supply, for

Pittsburg coal, 0.787 × 10.51 × 33.7 = 297.3 cu. m. = 373.46 kgs.
Hocking Valley coal, 0.787 × 9.27 × 37.1 = 269.7 cu. m. = 338.8 kgs.
Illinois coal, 0.787 × 7.67 × 42.9 = 258.95 cu. m. = 325.29 kgs.

The corresponding figures, with theoretical air supply, are for

	cu. m.
Pittsburg coal	228.7
Hocking Valley coal	207.5
Illinois coal	199.2

The carbon dioxide from the raw mixture is 90.93 kgs., and from the fuel is for

Pittsburg coal, $0.77 \times 33.6 \times \frac{44}{12} = 94.86$ kgs.

Hocking Valley coal, $0.67 \times 37.1 \times \frac{44}{12} = 91.15$ kgs.

Illinois coal, $0.56 \times 42.9 \times \frac{44}{12} = 88.07$ kgs.

We have then a total of carbon dioxide for

Pittsburg coal, 185.79 kgs. = 93.9 cu. m.
Hocking Valley coal, 182.08 kgs. = 92.1 cu. m.
Illinois coal, 17.9 kgs. = 90.6 cu. m.

The gas analysis of the dry gases, with theoretical air supply, are then at 0° C.

	Cubic meters.			Per cent.	
	CO_2	N.		CO_2	N.
Pittsburg coal	93.9	228.7		28.9	71.1
Hocking Valley coal	92.1	207.5		30.7	69.3
Illinois coal	90.6	199.2		31.4	68.6

The corresponding figures, with 1.3 theoretical air supply, are:

	Cubic meters.				Per cent.		
	Total.	CO_2	O.	N.	CO_2	N.	O.
Pitts. coal..	408	93.9	16.8	297.3	23	72.9	4.1
H. Val. coal.	378	92.1	16.2	269.7	24.4	71.3	4.3
Ill. coal.....	365.15	90.6	15.6	258.95	24.8	70.9	4.3

Between the above limits it is possible to burn cement.

Three different kinds of coal have been calculated to show that the result is practically the same, with the same number of thermal units, and that the statement of coal consumption per barrel in pounds or kilograms is of no value without stating the calorific value of the coal in question. In my opinion any coal, which can be burnt on grates, can be used to burn cement if its constitution allows it to reach temperatures of 1,600° C and above and its ashes do not contain substances which will contaminate the cement. The main heat question in the burning of cement is then: Calorific value of fuel = consumption of heat units per barrel + heat of waste gases. We will now figure the heat of the waste gases for the different coals.

The heat of the waste gases is for:

Pittsburg coal, 33.6 (7,450 + 64) (1 — 0.1) — 51,925 = 227,222 — 51,925 = 175,300 calories.
Hocking Valley Coal, 37.1 (6,740 + 57) (1 — 0.1) — 51,925 = 226,951 — 51,925 = 175,000 calories.
Illinois coal, 42.9 (5,830 + 47) (1 — 0.1) — 51,925 = 226,941 — 51,925 = 175,000 calories.

We have then practically 175,000 calories to use under the waste gas boilers. To be able to calculate the size of boiler necessary to utilize the heat we have to calculate the temperature of the waste gases. For exact calculation I have used the formulas of Mallard and Le Chatilier varied by Langen* for O, N and O, $Cv = 4.8 + 0.0006\ t$ and for $C\ O_2$, $Cv = 6.7 + 0.0026\ t$ from which have been derived the relation, $\frac{2}{m} = Cp = Cv$; m = 32 for oxygen; m = 28 for carbon monoxide and nitrogen, and m = 44 for $C\ O_2$.

For N and C O, $c\ p = 0.24286 + 0.00004286\ t$.
For O, $c\ p = 0.2125 + 0.000,0375\ t$.
For $C\ O_2$, $c\ p = 0.19773 + 0.000,1182\ t$.

The formula of Weyranch* was used for H_2O,

For H_2O, $c\ p = 0.4304 + 0.000,3779\ t$.

The mean specific heat for the temperatures from t = 0 to t = t are then for

N and C O, $c\ p = 0.24286 + 0.00002143\ t$.
O, $c\ p = 0.2125 + 0.00001877\ t$.
$C\ O_2$, $c\ p = 0.19773 + 0.0000591\ t$.
$H_2\ O$, $c\ p = 0.4304 + 0.0001889\ t$.

Assuming that we have in the air at 20°, 16 grammes of water per cubic meter, we have then in the waste gases the following amounts of water vapor:

In using Pittsburg coal, from the coal	33.6 (0.014 + 9 × 0.5) =	15.59 kgs.
air	0.016 × 10.51 × 33.6 =	5.65 "
raw material		1.35 "
Total		22.59 kgs.
In using Hocking Valley coal from the coal	37.1 (0.05 + 0.048 × 9) =	17.88 kgs.
air	37.1 × 0.016 × 9.27 × 3 =	5.50 "
raw material		1.35 "
Total		24.73 kgs.
In using Illinois coal from the coal	42.9 (0.05 + 0.05 × 9) =	21.45 kgs.
air	42.9 × 0.016 × 7.67 =	5.25 "
raw material		1.35 "
Total		28.05 kgs.

The heat equation for Pittsburg coal is then:

$$\begin{aligned} 175{,}300 = t\ & 23.96\ (0.2125 + 0.000,01877\ t) \\ & 185.79\ (0.19773 + 0.000,0591\ t) \\ & 375.46\ (0.24286 + 0.000,02143\ t) \\ & 22.59\ (0.4304 + 0.000,1889\ t) \\ = 142.248\ t & + 0.023,7268\ t^2 \\ t = & \ 1{,}048° \end{aligned}$$

As we have 605.80 kilos of waste gases the mean specific heat would be:

$$c\ p = 0.267.$$

For Hocking Valley coal the equation is:

$$\begin{aligned} 175{,}000 = t\ & 23.15\ (0.2125 + 0.000,01877\ t) \\ & 182.08\ (0.19793 + 0.000,0591\ t) \\ & 338.8\ (0.2486 + 0.000,02143\ t) \\ & 24.73\ (0.4304 + 0.000,1889\ t) \\ = 133.23\ t & + 0.0227,735\ t^2 \\ t = & \ 1{,}086. \end{aligned}$$

We have 567.6 kilos of waste gases and the mean specific heat figures then:

$$c\ p = 175{,}000 = 0.283$$
$$1086,\ 568.76$$

For Illinois coal:

$$\begin{aligned} 175{,}000 = t\ & 22.26\ (0.2125 + 0.000,01875\ t) \\ & 179.00\ (0.19773 + 0.000,0591\ t) \\ & 325.29\ (0.24286 + 0.000,02143\ t) \\ & 28.05\ (0.4304 + 0.000,1889\ t) \\ = 131.19\ t & + 0.023 \times 2657\ t^2 \\ = & \ 1{,}113° \\ c_p = & \ 0.283. \end{aligned}$$

For approximate calculation the value Cp = 0.28 is exact enough for waste gases in the neighborhood of 1,000° C.

The heat of the waste gases, 175,000 calories, can be used under boilers, and if we estimate the efficiency of the waste gas boilers very low, say 65%, we have 175,000 × 0.65 = 112,750 calories.

The temperature of the steam at 150 lbs. pressure, equal to 10.5 atmospheres, is 185° C and a kilogram of steam contains 663 calories. Calculating on regaining 73 calories in heating the feed water by waste steam and the use of the condensed steam for feed water, 590 calories will generate 1 kilogram, and $\frac{113{,}750}{590} = 193$ kilograms of steam can be generated by waste heat. The General Electric Co. guarantees to develop one kilowatt with 20 lbs. of steam at 150 lbs. pressure and adding 30% at a very safe figure, for auxiliary machinery, we develop from the waste gases:

$$\frac{193 \times 22}{26} = 16.3 \text{ kilowatt hours per barrel.}$$

This power will in my opinion cover all the needs in an up-to-date cement plant. If more power should be needed we have only to burn more coal in the kiln. The burning of the cement is, in my opinion, nothing else than keeping a certain temperature in the kiln; the temperature can be kept with more or less coal, according to the gas velocity in the kiln, and this flexibility of the process allows taking care of the variations in the power requirements of the mill.

I do not wish to be misunderstood in this regard. I would not want to change the conditions of the kiln house if a break-down of several hours occurs in one department. But if the cement mill should be stopped on account of the warehouse being full, I am satisfied that I could regulate the coal feed and air blast to get less waste heat, viz.: burn less coal.

The first installation of waste gas boilers has always been looked upon as a very expensive affair, which it is no doubt in old mills where the buildings and the machinery are in the way, but in new mills the first cost for a waste gas boiler plant, is not so very much more than for direct fire boilers.

Waste gas temperatures of 1,000° C have been measured behind running kilns. The calculated figures are obtainable, and we have then with 185°C steam temperature and 280° waste gas temperature under the boiler, the mean difference of temperature of fire gases and steam in the boiler kilns fired with

Pittsburg coal ..... $= \frac{1048 + 280}{2} = 185 = 479°$

Hocking Valley coal ... $= \frac{1086 + 280}{2} = 185 = 498°$

Illinois coal ..... $= \frac{1113 + 280}{2} = 185 = 511°$

The coefficient of heat transmission is 3 B T U per sq. ft. per hour per 1° F. in standard American water tube boilers, which equals 14.65 calories per sq. m. per hour per 1° C.

As we have 113,750 calories to utilize, with a mean difference of about 480°C, we have

$$\frac{113{,}750}{14.65 \times 480} = \frac{113{,}750}{8{,}032} = 14.2 \text{ sq. m. of heating}$$

surface per barrel of cement; 14.2 × 10.76 = 1.53 sq. ft. per barrel. Prof. R. C. Carpenter has put behind two kilns, one boiler of 3,056 sq. ft. boiler surface and one economizer of

$$3{,}056 \times \frac{1{,}178{,}998}{8{,}798{,}328} = 3{,}056 \times 0{,}134 = 342 \text{ sq. ft.}$$

of boiler heating surface or a total of 3,400 sq. ft.

*Zeitschrift des Vereins Deutscher Ingenieure, 1903, p. 631.
*Zeitschrift des Vereins Deuscher Ingenieur, 1904, pp. 1 and 2.

for 21.1 barrels. This figures 161 sq. ft. per barrel of cement.

If we assume that we can burn, with automatic stokers, with 1.3 of the theoretical air supply and figure the efficiency of the fireplace N 2 = 95% and the coefficient of radiation d = 0.2 and the air temperature t = 20°. The above suppositions are very high and are only obtained with the very best amount of care and the very best installation. The temperature of ignition are then:

For Pittsburg coal: T (12.55 + 1) 0.24 = 0.95 × 7,450 (1 — 0.2) + 13.55 × 20.
T. 3,492 = 5062 + 64.
T = 1,640°.

For Hocking Valley coal: T. (11.88 + 1) 0.24 = 0.76 × 6,740 + 11.98 × 4.75.
T. 3.0812 = 5,122 + 56.
T = 1,680°.

For Illinois coal: T. (9.88 + 1) 0.24 = 0.76 × 5,830 + 9.88 × 4.75.
T. 2.611 = 4,430 + 47.
T. = 1,715°.

The mean difference of temperature between the fire gases and the steam is then, for

Pittsburg coal ..... $= \frac{1640 + 280}{2} - 185 = 775°$

Hocking Valley coal .... $= \frac{1680 + 280}{2} - 185 = 795°$

Illinois coal ..... $= \frac{1715 + 280}{2} - 185 = 872°$

As the steaming capacity of the boiler is directly proportional to the mean difference in temperature, the waste gas boiler has to be made 1.6 times larger than the direct fired boiler. The repairs of the waste gas boiler with a maximum temperature of 1,100° are very much lower than the repairs of the boiler with a maximum temperature of 1,700°C.

Figuring the direct fired boiler with an efficiency of 75%, we would have to burn to generate 113,750 calories if we used

Pittsburg coal ..... $\frac{113,750}{0.75 \times 7450} = 20.3$ kgs.

Hocking Valley coal ..... $\frac{113,750}{0.75 \times 6740} = 22.9$ "

Illinois coal. ..... $\frac{113,750}{0.75 \times 5830} = 26.0$ "

According to these figures we use to burn cement only of

Pittsburg coal .....33.6 — 20.3 = 13.3 kgs.
Hocking Valley coal .....37.1 — 22.9 = 14.2 "
Illinois coal. .....42.9 — 26.0 = 16.9 "

I show below conclusively, I believe, that it is practically impossible to burn cement with 16.9 kilos of Illinois coal and thus prove that the waste gas boiler is the most economical solution of the problem.

We have, with 16.9 kgs. of coal in the waste gases,

Water from the coal	16.9 × 0.50 =	8.45 kgs.
air	16.9 × 0.016 × 7.67 =	2.07 "
raw material	=	1.35 "
Total		11.87 kgs.
Oxygen: 0.3 × 1.73 × 16.9 =		8.77 kgs.
Carbon dioxide, from the coal	$0.56 \times 16.9 \times \frac{44}{12}$ =	34.7 kgs.
raw material		90.93 "
Total	63.5 cu. m. =	125.63 kgs.
Nitrogen: 0.787 × 7.67 × 16.9 =	102 cu. m. =	128.1 kgs.

The total waste gases, dry, would then be

	Cu. m.	Per ct.
Oxygen	6.2	3.7
Carbon dioxide	63.5	36.9
Nitrogen	102.0	59.4
Total	171.7	100.0

The air for combustion cannot be used very much hotter than 600°, and we can only use then 600. × 2.35 × 16.9 = 23,829 calories, and lose, therefore, 38,196 — 23,829 = 14,367 calories.

The heat equation is then:

16.9 (5,830 +47) (1 — 0.1) = 51,925 + 14,367.
+ t 8.77 (0.2125 + 0.000,0187 t)
125.63 (0.19773 + 0.000,0591 t)
128.1 (0.24286 + 0.000,0214 t)
11.87 (0.4304 + 0.000,1889 t)
t = 350.

The temperature of the waste gases would then go down to 350°C. = 620°F., and I do not believe that it is possible to lengthen the kiln enough to come down to this temperature with the dry process. The wet process is more or less a thing of the past in this country, and the installation of the waste gas boiler behind rotary kilns will have a tendency to hasten its end.

To recapitulate the figures, we have:

	Calories.	Per ct.
Heat units from combustion of coal....	250,000 =	100
Heat units used to burn cement including kiln loses	51,925 =	20.8
Heat units leaving the kiln	175,000 =	70
Heat units available in the steam	113,750 =	45.5

According to Professor Carpenter's figures in the "Sibley Journal of Engineering," March, 1904, page 232, the heat from the combustion of coal = 26,450,000 B T U = 100%, and the heat absorbed by boiler and economizer, 8,798,328 + 1,178,998 = 9,977,326 B T U = 37.7%.

The first test with waste gas boilers published comes then, with 37.7%, very near to the calculated 45.5% of the heat units supplied to the process by the combustion of the coal.

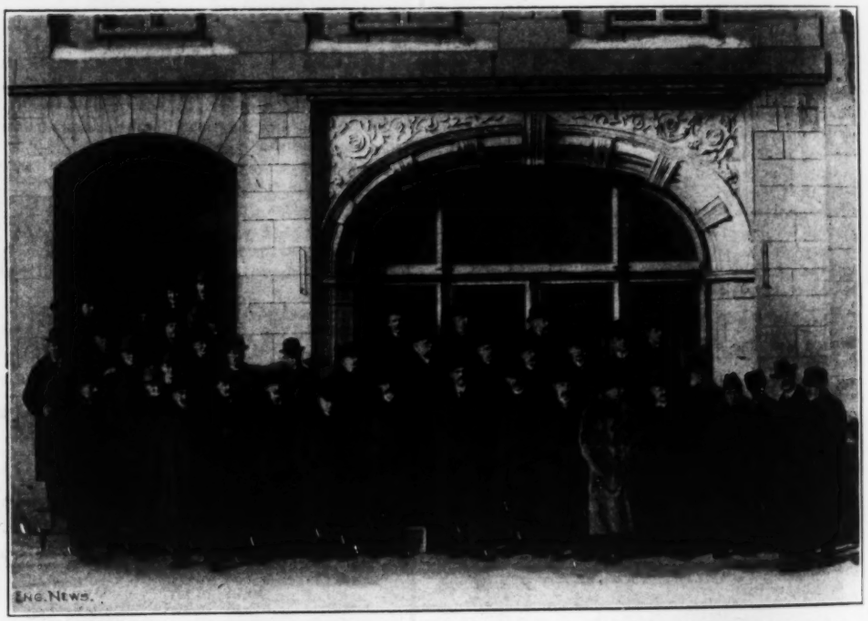
Figuring a barrel of cement at 380 lbs, $\frac{8,018}{380}$ = 21.1 barrels of cement, or 1 barrel = $\frac{9,977,326}{21.1}$ = 472,900 B T U.

42.2900 × 0.252 = 118,944 calories.

The heat units derived from the coal per barrel are $\frac{26,450,000}{21.1}$ = 1,253,000 B T U = 315,756 calories.

THE CONVENTION OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

The accompanying group photograph was taken in front of the house of the Canadian Society of Civil Engineers, at 877 Dorchester St., Montreal, during the recent annual convention of the Society. The photograph shows the front of the handsome premises secured by the Society in 1900, and is interesting as showing also evidences of Canadian weather conditions, the thermometer registering 20° below zero at the time the photograph was taken. Those forming the group are chiefly members resident in Montreal and in the Province of Quebec. The members from Toronto were delayed by a storm, and had not arrived when the photograph was taken.



MEMBERS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS IN FRONT OF THE SOCIETY'S HOUSE, MONTREAL, JAN. 25, 1905.

TANK LOCOMOTIVES FOR SUBURBAN SERVICE ON AMERICAN RAILWAYS.

For many years it was the common custom of American railway managers to use for hauling suburban trains any old locomotives which had become outclassed for regular passenger service, but were still safe to run. The growth of suburban traffic, however, has compelled a change in this respect on most roads. It has become necessary to haul very heavy trains and to make fast time notwithstanding frequent stops. This means that trains must be rapidly accelerated, and to do this without slipping the driving wheels means that weight must be concentrated there. This has led the recent trial by several railways of tank locomotives for suburban traffic, and this departure has been facilitated by the fact that most suburban runs are so short that a moderate water and coal space is sufficient to carry the engine through the run.

In Europe the use of the tank locomotive has always been greater than in this country, partly for the reason that locomotive runs are generally shorter and partly because smoother track and easier curves has enabled locomotives without leading trucks to be generally used. It is also a fact, of course, that suburban traffic had developed on a large scale there years before it had assumed any considerable proportions here.

In order to present a general summary concerning the use of tank locomotives for suburban service in this country, we have been at the pains to collect a considerable amount of information at first hand from a number of leading railways and present it as follows:

CENTRAL R. R. OF NEW JERSEY.—This company has a considerable suburban traffic along its main line from New York City as far west as Bound Brook and Somerville, N. J. Most of the suburban towns served are so far from the terminus that high-speed running is demanded. The company has introduced tank engines of the Prairie type (2-6-2); they haul trains of 2 to 10 cars, the weight per car varying from 55,000 to 62,000 lbs. Eight-wheel (4-4-0) engines with tenders, and having cylinders 18 × 24 ins. and 19 × 26 ins. were formerly used in this service, but could not accelerate the trains fast enough. The new engines, Fig. 1, were built by the Baldwin Locomotive Works in 1903, and run from Jersey City to Perth Amboy, 21.1 miles, and to Somerville, 34.7 miles. The engines have tanks at the sides of the boiler, and Mr. W. M. McIntosh, Superintendent of Mo-

tive power, states that side tanks are preferred to rear tanks on account of the shorter wheelbase and the greater weight on the driving wheels. The engines are very satisfactory from both a mechanical and an operating standpoint, and in his opinion tank engines are far superior to tender-engines for suburban traffic. The following is a summary of the service operated by these engines, and it will be seen that in one run of 21 miles there are 20 stops, requiring a very high speed between stops, although the average speed for the entire run is not high:

	Distance, miles.	No. of cars.	No. of stops.	Time, mins.	Av. speed, miles per hr.
J. City to P. Amboy..	21.1	2	9	45	28.0
" ..	"	2	20	52	24.3
P. Amboy to J. City..	"	2	2	32	39.6
" ..	"	2	11	42	30.0
J. C. to Somerville...	34.7	6	12	69	30.2
Somerville to J. C....	"	6	18	80	26.0

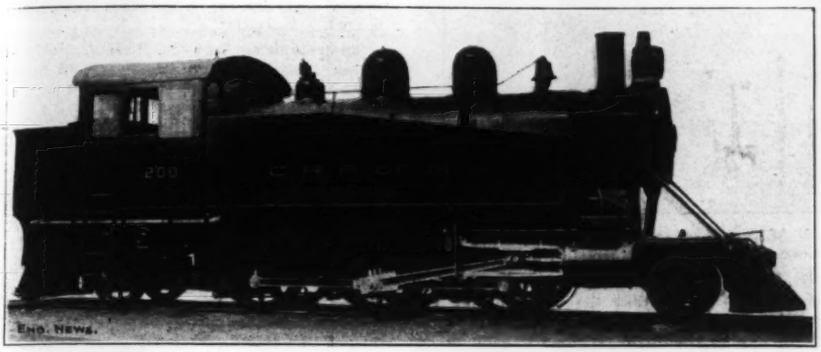


FIG. 1. TANK LOCOMOTIVE FOR SUBURBAN SERVICE; CENTRAL RY. OF NEW JERSEY.
W. M. McIntosh, Superintendent of Motive Power; Baldwin Locomotive Works, Philadelphia, Builders.

CHICAGO & EASTERN ILLINOIS RY.—This road has had in its Chicago suburban service a number of tank engines (with rear tanks) of the 2-6-6 class. Most of these were built by the Schenectady Locomotive Works in 1892 and 1893. Since the railway began using the new La Salle St. terminal station, however, a few months ago, it has given up most of its suburban and terminal business, and some of the engines have been leased to the Chicago Terminal Transfer Ry. The dimensions of these engines are given in Table I. The road has also used some smaller engines of the 2-4-4 class, with cylinders 17 × 24 ins., a weight of 61,700 lbs. on the driving wheels and a tank capacity of 1,990 gallons. The larger engines ran between Chicago and Crete, 30 miles, making eight stops, and having an average speed of 27 miles per hour. They usually hauled two cars, with a total weight of 91,200 lbs.

CHICAGO, BURLINGTON & QUINCY RY.—This road operates much of its Chicago suburban service with tank engines (having rear tanks) of a reversed mogul type, 0-6-2, having six driving wheels under the boiler and cab, and a trailing pony truck under the tank. These engines, one of which is shown in Fig. 2, were designed for suburban service between Chicago and Riverside, 11.1 miles, and Downer's Grove, 22.2 miles; they are also used somewhat less extensively between Chicago and Aurora, 37.5 miles. They usually make 14 stops with the Riverside trains and 19 stops with the Downer's Grove trains. These trains have from two to six cars, the average weight of which is about 47,000 lbs. The engines were built at the company's shops in 1899, and on account of the comparatively short runs a large capacity of coal and water was not considered necessary. Until these engines were built, the suburban trains were operated by eight-wheel (4-4-0) engines with tenders, having a weight of 55,000 lbs. on the driving wheels. The tank engines, with 64,000 lbs. on the drivers, are considered preferable. Mr. F. H. Clark, Superintendent of Motive Power, prefers the rear tank to the side tank, as it is more accessible and allows of boiler repairs being more easily made.

CHICAGO, ROCK ISLAND & PACIFIC RY.—This railway has in service six tank engines (with rear tanks) of the 2-6-6 class, which were built by the Baldwin Locomotive Works in 1893. The principal runs are between Chicago and Blue Island, 17 miles; there are also a limited number of trains between Chicago and Joliet, 40.4 miles. The number of stops is from 18 to 20, and the trains are composed of three to eight cars weighing about 60,000 lbs. each. The run of 17 miles is made in 45 minutes, including all stops. The engines are satisfactory from an operating standpoint, as they do not require to be turned. They are also satisfactory from the mechanical standpoint, except that some trouble is experienced in maintaining the connections of the main frames with the extension carrying the tank. This, however, is a detail easily provided for in a proper design.

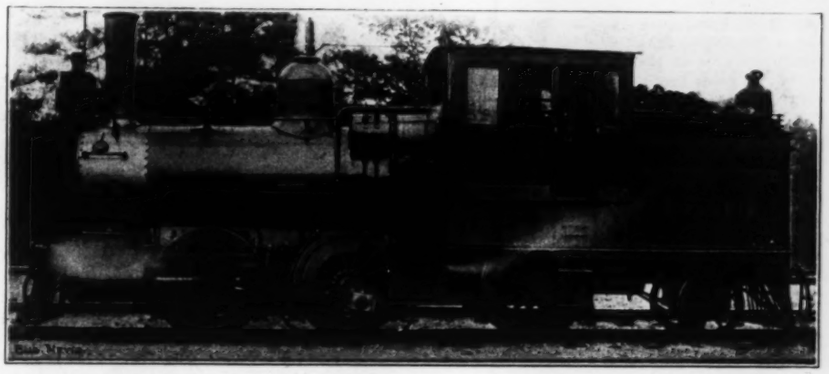


FIG. 2. TANK LOCOMOTIVE FOR SUBURBAN SERVICE; CHICAGO, BURLINGTON & QUINCY RY.
F. H. Clark, Superintendent of Motive Power.

ILLINOIS CENTRAL RY.—Probably the most extensive use of tank engines in this country is in the Chicago suburban service of the Illinois Central Ry. This road now has 40 tank engines, which were built at the company's shops and by the Rogers and Schenectady locomotive works. They are all of the rear-tank class, and in some of them the tank has a water leg extending under the cab. The engines are of the following types:

Class.	No.	Class.	No.
2—4—4	21	2—6—4	2
2—4—6	10	4—6—4	7
Total			40

The tank engines are considered satisfactory, both mechanically and from an operating standpoint. They are approved for suburban service on account of being more compact and cheaper to operate and maintain than the tender engines. They are also approved for this class of service where engines are run without being turned, the men on the tank engines being well protected when the engine is running with tank ahead.

For the following particulars as to the suburban service operated by these engines we are indebted to Mr. W. Renshaw, Superintendent of Machinery. In regard to the average speeds given in the table, it may be noted that express trains make the run from Randolph St. to Hyde Park (6.57 miles) in 13 minutes, including one stop at Van Buren St. and one at the combination switch just north of 12th St. The rate of speed, including these two stops, is 30.2 miles per hour, while the rate between Van Buren St. and Hyde Park (5.74 miles), including the stop at the switch, is 31.4 miles per hour. This means that the train must attain a speed of 55 to 57 miles per hour for

TABLE I.—TANK LOCOMOTIVES FOR SUBURBAN TRAFFIC ON AMERICAN RAILWAYS.

Railway	Cen. Ry. N. J.	C. & E. Ill.	C., B. & Q.	C., R. I & P.	Ill. Cen.	Long Id.	N. Y. Cen.	Phila. & Read.
Class	2—6—2	2—6—6	0—6—2	2—6—6	2—4—6	2—6—2	2—6—6	2—6—4
Tank	Side	Rear	Rear	Rear	Rear	Side	Rear	Rear.
Driving wheels	5 ft. 3 ins.	5 ft. 3 ins.	4 ft. 9 ins.	5 ft. 3¾ ins.	4 ft. 8½ ins.	5 ft. 3 ins.	5 ft. 3 ins.	5 ft. 1½ ins.
Front truck wheels	3 ft.	2 ft. 6 ins.	.....	2 ft. 6 ins.	2 ft. 9 ins.	3 ft.	2 ft. 6 ins.	2 ft 6 ins.
Rear truck wheels	3 ft. 6 ins.	2 ft. 6 ins.	3 ft.	2 ft. 9 ins.	2 ft. 9 ins.	3 ft.	2 ft. 6 ins.	2 ft. 6 ins.
Wheelbase, driving	14 ft.	12 ft. 9 ins.	14 ft. 4 ins.	13 ft. 4 ins.	6 ft. 10 ins.	14 ft.	15 ft.	12 ft. 6 ins.
Wheelbase, total	31 ft. 8 ins.	20 ft. 3 ins.	22 ft. 5 ins.	21 ft. 4 ins.	32 ft. 7 ins.	31 ft. 8 ins.	35 ft. 10 ins.	30 ft. 9 ins.
Total length	.....	46 ft. 11½ ins.	37 ft. 10 ins.	49 ft. 7 ins.	43 ft. ¾ in.	.....	48 ft. 1½ ins.	.....
Weight on drivers	129,000 lbs.	95,000 lbs.	94,000 lbs.	107,000 lbs.	72,000 lbs.	130,365 lbs.	128,000 lbs.	120,860 lbs.
Weight on front truck	21,900 lbs.	14,000 lbs.	.....	19,700 lbs.	17,500 lbs.	23,910 lbs.	24,000 lbs.	19,120 lbs.
Weight on rear truck	39,000 lbs.	62,000 lbs.	19,000 lbs.	68,000 lbs.	76,500 lbs.	34,540 lbs.	64,000 lbs.	61,720 lbs.
Weight, total	189,900 lbs.	171,000 lbs.	113,000 lbs.	194,700 lbs.	166,000 lbs.	188,815 lbs.	216,000 lbs.	201,700 lbs.
Cylinders	18x26 ins.	18x24 ins.	17x22 ins.	18x24 ins.	17x24 ins.	18x26 ins.	20x24 ins.	20x24 ins.
Valves	Slide	Slide	Slide	Slide	Slide	Slide	Piston	Slide
Boiler, diameter	4 ft. 10¼ ins.	4 ft. 8 ins.	4 ft. 3½ ins.	4 ft. 10 ins.	4 ft. 9 ins.	5 ft.	5 ft. 9 ins.	5 ft. 6 ins.
Boiler, pressure	200 lbs.	150 lbs.	160 lbs.	180 lbs.	150 lbs.	200 lbs.	200 lbs.	200 lbs.
Firebox	109x72 ins.	90x42 ins.	72x42 ins.	101½x33 ins.	95¼x84⅞ ins.	.....	92⅝x88⅝ ins.	105x94 ins.
Tubes, number	249	247	194	240	200	249	365	447
Tubes, diameter	2 ins.	2 ins.	2 ins.	2 ins.	2 ins.	2 ins.	2 ins.	1¾ ins.
Tubes, length	13 ft.	11 ft.	11 ft.	11 ft. 1 in.	10 ft. 10 ins.	13 ft.	12 ft.	9 ft.
Heat. surface; tubes	1,695 sq. ft.	1,360 sq. ft.	980 sq. ft.	1,226 sq. ft.	1,134.40 sq. ft.	1,684.0 sq. ft.	2,275.0 sq. ft.	1,825.5 sq. ft.
Heat. surface; total	1,834.6 sq. ft.	1,484 sq. ft.	1,064 sq. ft.	1,384 sq. ft.	1,250.83 sq. ft.	1,821.4 sq. ft.	2,458.0 sq. ft.	1,981.8 sq. ft.
Grate area	54.5 sq. ft.	26.2 sq. ft.	21 sq. ft.	23.26 sq. ft.	23.00 sq. ft.	54.5 sq. ft.	56.6 sq. ft.	68.5 sq. ft.
Water, gallons	3,000	2,450	1,650	2,600	2,500	2,400	3,700	3,000
Coal, tons	5	5	2½	4	6	5	5	3¾
Tractive power	22,700 lbs.	.....	.....	.....	16,570 lbs.	.....	27,000 lbs.	28,000 lbs.

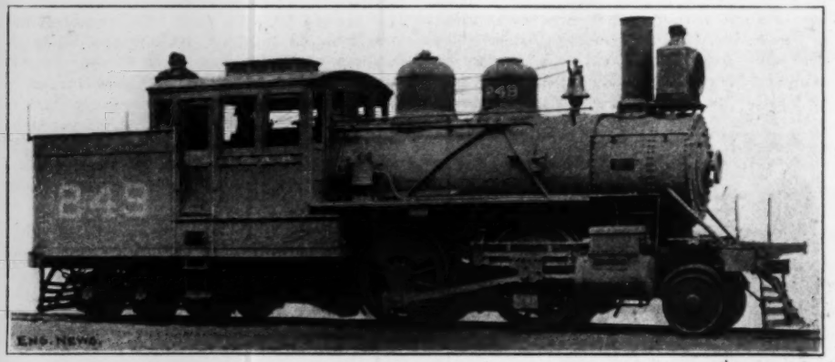


FIG. 3. TANK LOCOMOTIVE FOR SUBURBAN SERVICE; ILLINOIS CENTRAL RY.
W. Renshaw, Superintendent of Machinery; Rogers Locomotive Works, Paterson, N. J., Builders.

a large part of the distance in order to maintain the schedule time. This speed is frequently exceeded when an engineman wishes to make up time. The express and local trains on all the five runs have from four to six cars and weigh 84 to 126 tons, except that on the Woodlawn run the local trains have three to four cars and weigh 84 to 150 tons.

Suburban Service with Tank Locomotives: Illinois Central Railway.

	A	B	C	D	E
Run: Chicago to....	Flossmoor.	Blue Id.	So. Chicago.	Woodlawn.	Gd. Cross'g
Miles.....	24.92	18.94	12.91	7.90	9.48
Stops, express train	19	23	14	5	9
" local train...	31	34	24	15	19
Av. speed, includ. stops:					
Express trains..	26	21	22	28.6	26
Local trains.....	21	18	17	17	16

This road has been using double-end tank engines (with rear tanks) in the Chicago suburban service for 24 years, the first engines (with cylinders 15 × 22 ins.) having been received in 1880. The double-end type was preferred, as there was no means of turning the engines at the outside points of the trips. Tank engines were also considered preferable to the ordinary engines on account of the tank being considerably shorter and the coal space being shut off from the cab. The first engines, above noted, were of the 2-4-4 type, designed by Mr. Wm. Hudson, and built by the Rogers Locomotive Works; they had cylinders 15 × 22 ins.; driving wheels 56½ ins. diameter; wheelbase, 42 ft. 1 in.; weight, 59 tons, with 28 tons on the driving wheels. Engines built by the same works in 1893 were of the 2-6-4 type: cylinders, 18 × 22 ins.; driving wheels, 56½ ins.; driving wheelbase, 13 ft.; total wheelbase, 33 ft. 5 ins.; they weighed 80 tons, with 46 tons on the driving wheels. The dimensions of the latest engines (one of which is shown in Fig. 3) are given in Table No. 1, and these were also built by the Rogers Locomotive Works.

LONG ISLAND RY.—This road has used tank engines of different types for its suburban traffic, including side-tank and rear-tank engines. It also had at one time some 2-4-6 engines with rear tanks and the Mason-Fairlie steam truck. The latest engines for the heavy suburban traffic are some side-tank engines of the Prairie or 2-6-2 type, built by the Baldwin Locomotive Works in 1904. From each tank a pipe leads to a well in the coal bunker, so that the water in the two tanks is equalized and at water stations the water is delivered to the well. While the load on the driving wheels varies, of course, with the amount of water in the tanks, the minimum weight is ample for the service required, and the minimum ratio of tractive effort to adhesion weight is 1 to 4.5. The maximum tractive effort is 22,800 lbs. The rear truck is of the type designed by the builders for the modern classes of engines having trailing wheels behind the drivers, but where it is desired to keep the rigid wheelbase as short as possible. The truck, as applied to these suburban tank engines, has a swing of 5 ins. to each side of the normal central position. These engines have to pass curves of 108 ft. radius.

NEW YORK CENTRAL RY.—This road is using tank engines of the 2-4-4 and 2-6-6 classes, all with rear tanks. There are seven of the former class, which were built in 1888 and 1892, and these are in use on the New York and Putnam division between 155th St. (connecting with the elevated railway) and Yonkers, 8.1 miles. In 1901 and 1902, there were 16 of the larger engines, Fig. 4, built by the Schenectady Locomotive Works. Two of these, however, have been converted into tender engines, and probably eight more will be similarly converted, the remainder being kept in use on runs to points where there are no turntables.

In changing the engines, the tanks and rear trucks are removed, converting the engines to the mogul type (2-6-0), with standard tenders attached.

These tank engines (2-6-6 class) are in use between New York and Croton (34.42 miles) and New York and Yonkers (15.22 miles) on the Hudson Division, and between New York and White Plains (22.4 miles) on the Harlem Division. The trains have from three to eight cars, the light cars on the Harlem Division weighing about 35,000 lbs., while the new 60-ft. cars on the Hudson Division weigh about 85,700 lbs. With trains making 22 stops between New York and Croton the average speed is 27.3 miles per hour, including stops.

Mr. F. M. Whyte, General Mechanical Engineer, states that the tank engines are satisfactory from a mechanical standpoint, but that the enginemen do not like them, preferring to run engines head first all the time on account of the dust blowing into the cab when running backward. It was found that the men were having the tank engines turned whenever possible, and also that it was just as convenient to head the engine in the direction of movement, so that this has usually been done, except at Yonkers. The water capacity of the tanks is not sufficient for winter requirements for the runs between New York and Croton, so that it is necessary to take water at an intermediate station. This is objectionable, and therefore regular tenders are placed behind the engines on both divisions, except those running to Yonkers, at which place it is not convenient to turn the engines. With the rear tanks it was necessary to make the tank short so as to keep the length of the engine within certain limits, and the height and width of tank were also limited. With the standard tender behind these engines they are more generally available, instead of being restricted to certain service. The tank engines were originally introduced to give greater power and more rapid acceleration than the eight-wheel engines with tenders formerly used. These latter had cylinders 18½ × 22 ins.; 64-in. driving wheels, and carried a weight of 77,000 lbs. on the drivers.

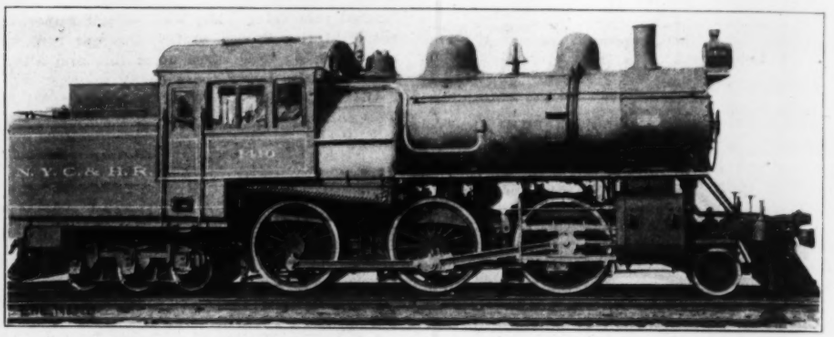


FIG. 4. TANK LOCOMOTIVE FOR SUBURBAN SERVICE; NEW YORK CENTRAL RY.
J. F. Deems, General Superintendent of Motive Power; American Locomotive Co., New York (Schenectady Works), Builders.

NEW YORK, NEW HAVEN & HARTFORD RY.—This road operates its suburban service at New York and Boston with various sizes of eight-wheel (4-4-0) tender engines and Forney tank engines (0-4-4). It has now 30 tank engines of the 0-4-2 class and four of the 2-4-2 class, all with rear tanks. The engines are considered satisfactory from the mechanical and the operating points of view, and Mr. F. N. Hibbits, Mechanical Superintendent, prefers tank engines where the length of run is such as to permit of their use. At Boston, the run is 12.13 miles, with 13 stations and a running time of 35 minutes. The trains consist of four cars, and weigh about 140 tons.

PHILADELPHIA & READING RY.—In 1892, this read put in service a Vauclain four-cylinder

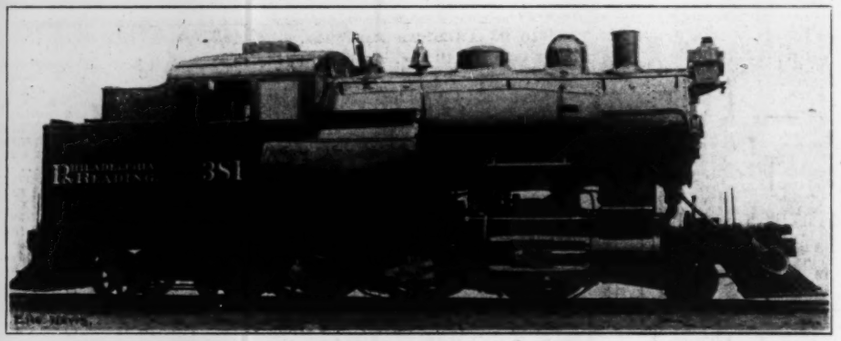


FIG. 5. TANK LOCOMOTIVE FOR SUBURBAN SERVICE; PHILADELPHIA & READING RY.
H. D. Taylor, Superintendent of Motive Power & Rolling Equipment; Baldwin Locomotive Works, Philadelphia, Builders.

compound tank engine (with rear tank), having a Wootten firebox and carrying 2,000 gallons of water. It was of the 2-6-6 class, with cylinders 12 and 20 ins. diameter, 24 ins. stroke; driving wheels, 61½ ins. diameter; 11-ft. driving wheelbase and 35-ft. total wheelbase. The weight was [illegible] tons, with 45½ tons on the driving wheels. In 1[illegible], tank engines (with rear tanks) of the 2-6-[illegible] class were introduced for operating the heavy Philadelphia suburban traffic of the Germantown and Chestnut Hill lines. These engines, Fig. [illegible], were built by the Baldwin Locomotive Works. One reason for adopting tank locomotives instead of tender locomotives was the quicker handling of the engines at the Philadelphia terminal (where there is a great congestion of traffic), as their use avoids the switching movements necessary to get an engine to and from the turntable. A powerful but flexible engine was required, with good acceleration, as there are numerous sharp curves and heavy grades, and there are ten stops in the first ten miles. The engines are designed to haul trains of six cars. One of the tank engines of the Central R. R. of New Jersey (already described) was experimented with on the line in question, and as a result a special type of engine was designed. On account of the sharp curves, the front truck is given a swing of 7 ins. to each side of its normal central position. The firebox is of the Wootten type. The road has had ten of these new tank engines in suburban service for a little more than a year, and Mr. H. D. Taylor, Superintendent of Motive Power and Rolling Equipment, states that their use is still an open question and that he is not yet prepared to furnish information as to their performance.

OTHER RAILWAYS.—Of other railways operating suburban service, Mr. T. S. Lloyd, Superintendent of Motive Power and Equipment of the Delaware, Lackawanna & Western Ry., reports that when suburban engines are ordered they will be the same as the standard passenger engines. The Pennsylvania Ry. reports that it does not use locomotives specially designed for suburban service, but uses locomotives that are interchangeable with those in through service. Mr. T. N. Ely, Chief of Motive Power, states, however, that in the future the demands of the suburban traffic may be such that a class of locomotives designed for that particular service can be used to advantage. The Chicago & Northwestern Ry. has no special suburban engines, but uses ordinary eight-wheel (4-4-0) tender engines. These have cylinders 18 × 24 ins., driving wheels, 63 ins. diameter, and weigh 45 tons, with 29 tons on the drivers. As to the merits of tank engines, however, Mr. Robert Quayle, Superintendent of Motive Power and Machinery, states as follows:

> There is not any question in my mind but that the regular suburban type of locomotive known as the tank locomotive is the proper type of locomotive. We get the adhesion, and can have, of course, large cylinder power to get the train in motion quickly. Our engines are not of that type, but I would much prefer to have them. I have no doubt that if the Chicago & Northwestern Ry. will continue to maintain its suburban service it means that it will at no distant time either get an engine of modern type for suburban service or else resort to electric power.

EFFECT OF LOAD FACTOR ON COST OF ELECTRIC POWER.*

By E. M. Archibald.

The great desideratum for an electrical system is a high load factor with consequent greatest return on investment, load factor being the ratio of average to maximum load. All the factors of expense included in cost of power to the consumer are then operating at maximum economy, and cost of power is at a minimum.

The lighting of residences and offices produces a peak in the late afternoon and evening, with but little load the remainder of the twenty-four hours; consequently the average load on the plant with lighting only is very small and the load factor low. A commercial motor load in connection with lighting will increase the average load even though causing a greater peak. The addition of a street railway load still further increases the day load, but in consequence of the heavy demand load during the rush hours, when the public is going to and from business, which occurs at the peak of the lighting load, the peak load on the plant is greatly increased. This heavy peak, with but a small average load over the twenty-four hours, produces a low load factor, and a portion of the machinery being shut down the greater part of the time, higher rates must be paid by the consumer to secure a certain return on first investment than when the load factor is higher.

Evidently, when the load factor is 100%, that is when the load is constant throughout the twenty-four hours, and all the machinery is in continuous operation, the cost of power per KW.-hr. is a minimum, and the greatest return on investment is realized. Customers having a steady load or with high average load are greatly desired and may be offered much better rates than all others. It will be the endeavor of this paper to determine the decreased cost of power with increasing load factor.

The storage battery is evidently a means in the hands of the power producing company of increasing the average load on the machinery. By charging the battery during light load and discharging during periods of heavy load, a more constant load on the generating apparatus is produced, with consequent better efficiency, and at the same time acting as a reserve in case of accident in the power plant. Unfortunately the battery is expensive, and a loss occurs in its operation which greatly reduces the higher efficiency secured by the increased load factor. The great benefits obtained by its use are reserve capacity and voltage regulation, enabling the use of more efficient lamps. The storage battery, however, has not been considered in what follows, even where it might be desirable, but rather a plant is assumed of certain maximum capacity for the peak load, and we are to determine what effect various load factors have on the cost of power produced.

The various expenses involved in the cost of power to the consumer are as follows: (1) Management; (2) Distribution; (3) Production. For a given system with given peak load the cost of management is practically constant, no matter what the load factor. The cost of distribution is constant with various load factors in so far as the fixed charges and maintenance is concerned. The losses in distribution, however, vary, these consisting of losses in lines, transformers if alternating current is used, meters, losses in grounds, and losses from theft of current; all decrease the output and accordingly increase the cost to the consumer. While it is possible to determine fairly accurately the losses in lines, transformers and meters with varying load factors, the losses from grounds and theft are indeterminate and require constant attention to keep them within certain limits. Yet as a rule these latter will become a smaller percentage of the total output the higher the load factor. There yet remains for consideration the effect of the load factor on the actual cost of production of energy.

The higher the load factor, the greater is the amount of power produced, the longer does the apparatus operate most efficiently, the lower the ratio of fixed charges to total operating expenses and consequently the lower the cost of power per unit.

To determine exactly in what proportion the cost of power is decreased, it will be necessary to assume a plant, determine the fixed and variable charges and thereby the cost per KW.-hr. at various factors.

Let us take for example a plant with a peak load of 750 KW. Allow three units of 300 KW. capacity each, so that in case of breakdown of one, the other two may take care of the peak with an overload of 25% on each and sufficient boiler capacity for the same contingency. No provision is allowed for stokers, coal handling apparatus or economizers. Plant assumed to be on the water front, providing sufficient water for condensing purposes.

Curves are plotted for this plant and also for a second plant of the same capacity as the first, but operating non-condensing. In both cases either water or railroad connections are assumed with convenient facilities for coal handling and removal of ashes.

FIRST COST OF PLANT COMPLETE:

Condensing, $118,425.00; equivalent to $131.60 per KW.
Non-condensing, $114,625.00; equivalent to $127.40 per KW.

FIXED CHARGES.	Condensing.	Non-Condensing.
Interest at 5%	$5,921.25	$5,731.25
Taxes and insurance at 2%	2,368.50	2,292.50
Depreciation machinery 10%	7,710.00	7,365.00
Building 3%	1,122.00	1,134.00
Total	$17,121.75	$16,462.75

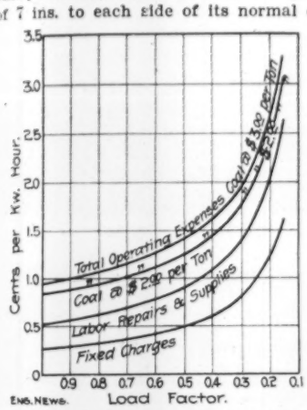


Fig. 1. Operating Cost, Engines Condensing.

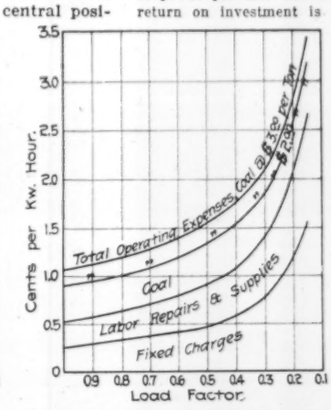


Fig. 2. Operating Cost, Engines Non-condensing.

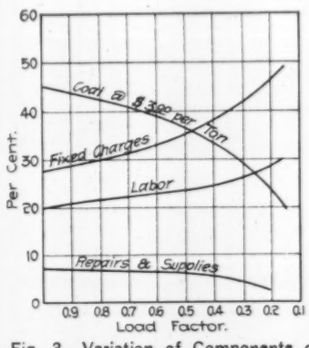


Fig. 3. Variation of Components of Operating Cost with Load Factor; Engines Condensing.

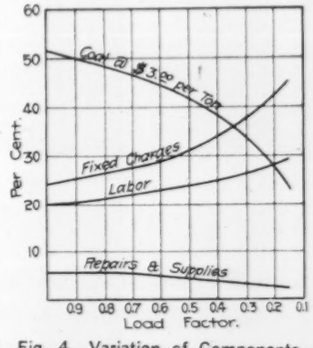


Fig. 4. Variation of Components of Operating Cost with Load Factor; Engines Non-Condensing.

FIGS. 1-4. OPERATING COST FOR VARYING LOAD FACTORS; 900-KW. STEAM PLANT (PEAK LOAD 750 KW).

The above first cost being for 100% load factor, there will be a varying reduction due to the decreased boiler capacity required on lower load factors. A point is reached below which it is not advisable to further decrease the boiler capacity as the peak load must be taken care of and sufficient reserve provided for accidents and repairs; this point being taken in this case at 40% load factor. The effect of this reduction is to diminish the fixed charges at 40% load factor by $1,000.00 per year, or about 6% of the total. From these figures the lower line in Figs. 1 and 2 is plotted; it indicates the effect of fixed charges on the cost of power.

The remaining items of expense are what are generally termed operating charges and are variable with load factor. These consist of (1) Labor, oil and waste, supplies, water and repairs; (2) Fuel.

The cost of labor varies to a certain extent with load factor, but a minimum number of men required to operate the plant is reached at about 40% load factor, below which this item remains constant. The cost of oil and waste, supplies, water and repairs varies almost directly with load factor as the greater number of hours per day that the machinery remains in service, the greater do these expenses become, and vice versa. The second line in Figs. 1 and 2 is for these charges reduced to the KW.-hr. basis, added to the fixed charges curve; the difference between the two curves therefore represents the cost of labor, oil and waste, supplies, water and repairs.

The cost of fuel, usually coal, per unit of power generated, varies with some power of the load factor, less than one, depending upon the number and efficiency of units employed both in the engine and boiler rooms, also upon the cost per ton of coal, its heating value, and upon the ability of the firemen to get the best results; it is of the utmost importance to watch this item carefully, as greater economy can be secured in the cost of coal than in any other item of expense. The calorific value of the coal should be tested from time to time and compared with the coal-rate.

The coal considered is assumed to contain 12,000 B.T.U. per lb., and two curves are plotted in Figs. 1 and 2 when the cost is $2.00 and $3.00 per ton respectively, the results being added to the two previous curves plotted. These figures of fuel cost per KW.-hr. are above the aver-

*A paper read before the Canadian Society of Civil Engineers at its annual meeting, Montreal, P. Q., Jan 26, 1905.

age usually obtained and can only be secured by constant attention in the boiler room; for instance at 40% load factor in the first case one kilowatt-hour is generated from 3.5 lbs. of coal from the pile.

The ratio of the individual items of expense to total operating expense is shown by Figs. 3 and 4 for the condensing and non-condensing plants respectively with coal at $3.00 per ton delivered. It is interesting in this connection to note the high percentage of fuel cost; in the average plant this percentage will be still higher than that shown, but this indicates how great a factor is the cost of fuel particularly with high load factors. For low load factor the fuel is subordinated by the fixed charges, which is by far the heaviest item.

Having thus determined the cost of power for a plant with a peak of 750 KW., we shall consider briefly a larger plant and ascertain what extra economies may be secured. This plant we shall assume to have a peak load of 1,500 KW., and a maximum capacity of 1,800 KW., divided into three units of 600 KW. each. Stokers are used, but no economizers or coal handling apparatus; the boilers are in a single line parallel to the engine room, and coal is dumped from the car into a chute, whence it falls to the floor of the boiler room.

First cost of this plant at 100% load factor is $241,125.00, equivalent to $134.00 per KW. Fixed charges, total percentage loss will be constant. Further, this lost power reduces the amount of sales, therefore affecting all the expenses included in cost to customer.

Fig. 7 shows a series of curves plotted for the 1,800 KW. steam plant, the lower line representing cost of production; the second, cost of distribution; third, cost of management, and fourth the effect of distribution losses on cost of power, this last being the final cost to consumer.

Coal is expensive, and from the nature of things will increase in price, and it behooves us to investigate any methods of producing power which is more economical in the use of fuel than the steam engine, and naturally turning to the gas engine we will next proceed to make a comparison between a steam plant and a gas plant generating producer gas for use in gas engines, and from such comparison deduce some general results.

As is well known the gas engine has a very much higher thermal efficiency than the steam engine, which fact, together with the fewer number of auxiliaries required, would naturally lead one to suppose that a greater economy could be secured in the production of power.

Difficulties, however, are encountered at the outset in the kind of fuel that may be used successfully in the gas producer. While the gas generated from anthracite coal is very successful in the operation of gas engines, for reserve, it is more advisable to use the same number of producers for all load factors and a small amount of storage for uniformity of gas and sudden peaks. Further the extra storage capacity required for small load factors costs about the same as an extra producer.

The operating costs for oil, water, repairs, supplies and water have been taken practically the same as for steam, as there are not sufficient reliable data at hand on this subject at the present time. Cost of labor is somewhat cheaper—for the type of producers considered only one man is actually required.

In Fig. 8 are given curves for cost of power with varying load factor for this 900 KW. gas plant. A comparison of Figs. 1, 2, and 8 shows a greater economy for the gas plant at the higher load factors, but poorer economy at low load factors due to the influence of the heavy fixed charges. The higher the cost of coal the greater is the economy of the gas over the steam plant at high load factors.

It must be remembered that the fuel economy in the case of the steam plants is taken considerably higher than the average and can only be secured by constant and careful attention to all the details around a power plant; in the gas plant the fuel at 50% load factor is taken at 1.4 lbs. coal per B.HP.-hr., which is somewhat higher than the manufacturers will guarantee. No matter how the fuel

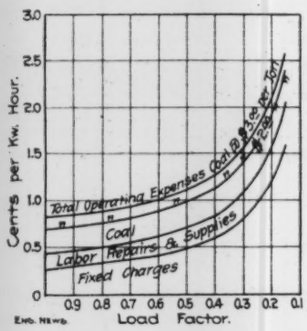


Fig. 5. Actual Operating Cost.

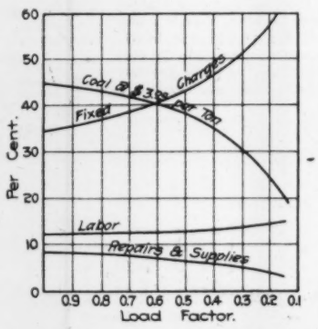


Fig. 6. Variation of Components of Operating Cost with Load Factor.

FIGS. 5 AND 6. OPERATING COST FOR VARYING LOAD FACTORS; 1,800-KW. STEAM PLANT (PEAK LOAD 1,500 KW). ENGINES CONDENSING.

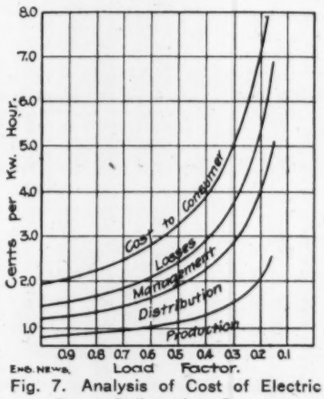


Fig. 7. Analysis of Cost of Electric Power Delivered to Consumer.

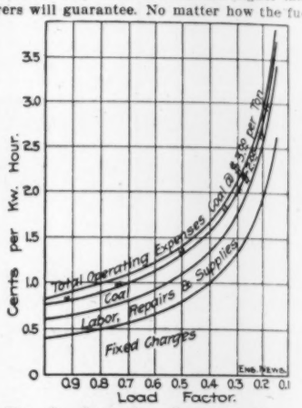


Fig. 8. Operating Cost for Varying Load Factors; 900-KW. Producer Gas Plant (Peak Load 750 KW).

using the same per cent. for interest, depreciation, taxes and insurance as in the previous case, become $36,318.75 per year. Curves are plotted in Fig. 5 for fixed charges, labor, supplies and repairs, and fuel, the latter being plotted for the two prices $2.00 and $3.00 per ton as before.

With all these curves before us it might be well to make some deductions as to the advisability of further expenditures in the power plant in coal handling apparatus and economizers, or in general, any apparatus that tends to increase the economy.

The higher the load factor the greater becomes the ratio of variable to fixed charges, and extra investment is advisable to secure the greatest economy possible. Extra investment in coal handling apparatus and economizers will reduce the cost of labor and fuel in greater proportion than fixed charges are increased; the economizers also provides greater boiler capacity and purer feed water, reducing cost of repairs. On the contrary when the load factor on a system is low, the fixed charges are the governing factor in the cost of power, and extra expenditures must be carefully considered, particularly so if fuel is cheap.

Having thus discussed the effect of load factor on the cost of producing power, we shall next turn to the cost of management and distribution. While it is beyond the scope of this paper to fully consider these costs, yet it was thought advisable to indicate by a curve including all the various costs approximately, how the load factor influences the cost to the consumer. This is done very generally, as no two cases are alike; the cost of distribution is more variable with different systems than is the cost of power, depending on the conditions of distribution, conduit or pole line construction, and the extent and density of the territory to be covered.

We shall allow that $50,000 per year covers all fixed charges, maintenance and attendance on the distributing net work; $35,000 per year for management, dividends on stock and miscellaneous expenses. For total losses 30% of the output is allowed; this is taken constant for all load factors, for while the percentage of known losses varies directly with load factor, the percentage of indeterminate losses by grounds and theft varies inversely as the load factor. The actual losses from grounds are constant, hence percentage loss by grounds varies inversely as load factor; losses from theft usually occcur with customers having a short hour load, and the greater the amount of such load connected, the greater this loss. A customer having a long hour load runs a greater chance of detection than others. Hence, the above statement holds that the the gas from bituminous coal contains tar which, when carried through the valves into the cylinders of the engine, clogs the valves and carbonizes under the intense heat to which it is subjected in the cylinder, preventing successful operation. Some manufacturers claim to have succeeded in removing the tar or preventing its formation, but the burden of proof still rests with them.

The overload rating of the gas engine is different from the steam engine in the ratio of about 15 to 50%. Hence in designing two plants, steam and gas, for equal overload capacities, it is necessary either to use gas engines of 25 to 35% higher normal rating, with consequent poorer economy at normal load; or add an extra engine and generator sufficient to take care of the extra overload capacity of the steam engine over the gas engine. For example, in designing a gas plant of 900 KW. capacity with a peak load of 750 KW., allowing the same reserve as in the steam plant considered previously, three engines of 530 B.HP. each will be required with an aggregate normal B.HP. of 1,590 and maximum B.HP. of 1,830, as compared with three 450 I.HP. equivalent to 410 B.HP. engines aggregating 1,230 normal B.HP. and 1,840 maximum B.HP.; or three gas engines of 410 B.HP. each and an additional engine of 360 B.HP. aggregating 1,830 B.HP. on maximum load (from a practical standpoint, this additional engine would be made of the same capacity as the rest, the cost being the same). In the first case at normal load on the generators the engines are 30% underloaded with consequent poor efficiency; in the second case the first cost will be greater, due to the extra generator and increased size of building required.

Allowing the same reserve capacity in producers, and with three 530 B.HP. gas engines direct connected to 300 KW. generators running at 100 r.p.m. the first cost becomes $167,650.00, equivalent to $186.00 per KW.

Fixed charges:	
Interest at 5% on $167,650	$ 8,382.50
Depreciation on machinery 10%	13,340.00
Depreciation on buildings 3%	1,005.00
Taxes and Insurance 2%	3,353.00
Total	$26,080.50

The storage capacity at 100% load factor is small, about 20,000 cu. ft., and is provided more for uniformity of gas than for storage. In case of accident to one producer, a second may be under way producing gas inside half an hour. The question of storage is important, particularly at small load factors when storage may be provided for the peak and a constant load maintained on the producers. In a plant of this size where the number of producers actually required is not over two with a third costs may vary from those given in these curves, they are relatively of far greater importance when the load factor is high than when it is low.

THE COMPUTATION OF STRESSES IN THE BLACKWELL'S ISLAND BRIDGE.*

By R. C. Strachan,†

The computation of the stresses in the trusses of the Blackwell's Island Bridge‡ over the East River at New York City presents a number of unusual features, and the following outline of this part of the design of the structure has been prepared in the belief that a discussion of the principles applied and of the methods employed in the solution of the problem may be of interest. The calculations were made by the writer for the Department of Bridges of the City of New York during the years 1902 and 1903, and have more recently been revised to conform to altered data.

As a preliminary, it will be well to state that, of the earlier great cantilever bridges, that over the Niagara (1883) has a main span of 495 ft.; the Poughkeepsie Bridge (1887) has three cantilever spans, of which the longest is 550 ft.; the Lachine Cantilever (1887) has two spans of 408 ft.; the Red Rock Cantilever, over the Colorado (1891), has a span of 660 ft., and of the four spans of the Memphis Bridge, over the Mississippi (1892), the longest is 790 ft. The 1,710-ft. span of the Forth Bridge, in Scotland, and the 1,800-ft. span of the Quebec Bridge over the St. Lawrence, now building, are the only ones of this type within the writer's knowledge which exceed in length the West Channel span of the Blackwell's Island Bridge.

The magnitude of individual parts is made clearer by a few comparisons: A substantial highway bridge, 150 ft. long, designed to carry a live load of 1,000 lbs. per ft., and having a roadway 16 ft. wide, will require about 30 tons of steel in its construction; while a single-track truss bridge 100 ft. long, designed to carry two locomotives of 177½ tons each, followed by a train weighing 5,000 lbs. per ft., will require about 70 tons. One of the floor-beams of the Blackwell's Island Bridge will weigh 16 tons, one of the main vertical posts 56 tons, and a panel-length of bottom chord near one of the piers 74 tons.

The bridge (shown in outline in Fig. 1 herewith) consists

*A paper read before the Brooklyn Engineers' Club, Jan. 9, 1905.

†Asst. Engr., Department of Bridges, New York City.

‡See Engineering News of Sept. 3, 1903, pp. 206 to 210, for extracts from the contract drawings and specifications for this structure.

of five spans, namely: Manhattan (west) Anchor span, 469.5 ft.; Channel span, west of Blackwell's Island, 1,182 ft.; Island span, 630 ft.; Channel span east of Blackwell's Island, 984 ft.; Queens Anchor span, 459 ft.; making a total length of 3,724.5 ft. The floor is double deck, carrying on the upper two elevated railroad tracks, so placed as to leave room for two more, to be built in future, and two promenades of 11 ft. clear width each. The lower deck carries a roadway 36 ft. wide, and four surface railroad tracks, two inside the trusses, and two outside on brackets—making the extreme width of the bridge 86 ft., except at the piers. The trusses are two in number, 60 ft. center to center, with depth varying from 185 ft. at the towers to 45 ft. at mid-channel, and 48 ft. at portals; the clear height above mean high water in either channel being 135 ft., as required by the War Department. The truss is of 61 panels, each subdivided by a system of secondary members into two semi-panels, the lengths of which vary from 20 ft. 6 ins. to 40 ft., and both upper and lower floor-stringers span one semi-panel from beam to beam. The system of designating panel points is shown in Fig. 2.

The simple span suspended between the separated cantilever arms, a usual feature in this type of bridge, is not present in this design, but, instead, the cantilever arms are continued until they come together at the centers of the two channel spans.

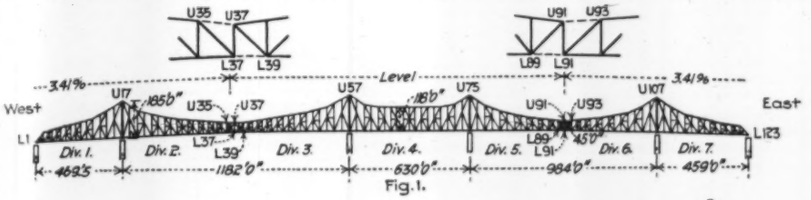


Fig. 1.

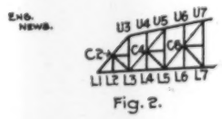


Fig. 2.

Fig. 3.

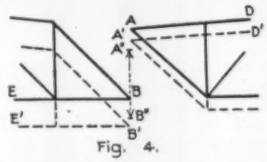


Fig. 4.

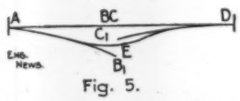


Fig. 5.

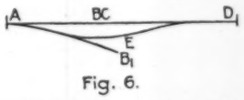


Fig. 6.

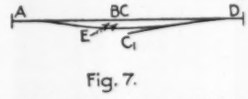


Fig. 7.

THE BLACKWELL'S ISLAND BRIDGE OVER THE EAST RIVER, AT NEW YORK CITY. DIAGRAMS ILLUSTRATING STRESS-COMPUTATION.

So far as concerns truss-action, the upper-chord members 35-37 and 91-93 and the lower-chord members 37-39 and 89-91 have no function, and the verticals or rockers at 37 and 91 serve to connect the cantilever arms. At these points and at the pier on the east side of Blackwell's Island provision is to be made for motion due to variation in temperature.

For convenience, the subdivisions are designated by the numbers 1 to 7, as shown in Fig. 1. Divisions 1 and 2 constituting the West Truss, Divisions 3, 4 and 5 the Middle Truss, and Divisions 6 and 7 the East Truss.

The maximum possible live load was, in the first instance, estimated as follows:

2 El. Ry. Trains @ 1,700 lbs. per ft.	3,400	lbs. per lin. ft.
4 Lines of Surface Cars @ 1,000 lbs. per ft.	4,000	" " "
35.5 ft. Roadway @ 100 lbs. per sq. ft.	3,550	" " "
22 ft. Promenades @ 75 lbs. per sq. ft.	1,650	" " "
Total on bridge	12,600	" " "
For one Truss	6,300	" " "

The maximum *probable* live load was estimated to be one-half of this, or 3,150 lbs. per ft. per truss. The very remote possibility of a live load of 6,300 lbs. per ft. per truss was therefore provided for by proportioning main truss-members for stresses due to this loading at a relatively high unit stress, or for stresses due to 3,150 lbs. per ft. at a lower unit stress. Secondary truss-members are all designed for the greatest possible congestion in any single panel.

The subsequent addition of two elevated railroad tracks, giving a total "congested" live load of 8,000 lbs., or "working load" of 4,000 lbs. per ft. per truss, made necessary a revision of both dead and live load stresses; and the results herein given are based upon the latter load.

The connection of the cantilever arms at mid-channel causes a load on any subdivision of the bridge to produce stresses in all the others; the effect, however, upon the East Truss of a load on the West Truss, or vice versa, is generally small, as will appear when the results are examined. Moreover, the simultaneous and complete stoppage of all the many lines of traffic in such a way as to give full live load on two widely separated subdivisions (Divisions 2 and 7, for example), and nowhere else, is practically out of the question, as is the assumption of live load covering any short isolated portion of the bridge.

Stresses for seven positions of live load were therefore calculated, the load in each case covering one of the seven subdivisions; and the maxima, both tensile and compressive, obtained by combining these for a continuous load extending over one or more subdivisions are the governing stresses for the main members of the truss.

In the absence of any similar truss with which to compare, weights were obtained by successive approximation, after the study of a sufficient number of members of each class had made possible a reliable estimate of the percentages for details. Those stresses, due to either dead or live load, which are unaffected by the action of the rockers, were obtained graphically and checked by analytical methods, more especially to detect errors in scaling, since the proper closing of the graphic diagrams constitutes a check upon the graphical work itself. The results of the action of the rockers were ascertained analytically.

Since the latter are dependent upon deflections, we must, in order to proceed, have an approximation to the sectional area of each truss member, although for the first trial a more or less roughly estimated deflection must suffice. Assuming that the preliminary work has been performed, and that the tentative area for each member has been fixed, the true stresses are then to be found. The amount contributed to the dead load deflection by play in pin-holes is so small a proportion of the total, that it would not be affected even though an upward force reduced that total by an amount equal to the entire live load deflection. Play in pin-holes is consequently eliminated as a factor, so far as live load truss-deflections are concerned.*

If we assume the rockers to be removed, the West Truss, Middle Truss and East Truss become three separate statically determinate structures, for which the stresses are readily found when the loading is known. Denote these by S_s. The replacing of the rockers causes a change in the amount of the deflection, and hence, a positive or negative reaction at the end of the cantilever arm, the effect of which is to cause stresses, sometimes acting with, sometimes against S_s. Denote these by S_r and the true stresses by S. Then

$$S = S_s + S_r \quad \ldots\ldots (1)$$

S_r may be of the same or opposite sign as compared with S_s.

In fabrication, the geometrical length of each member is increased or diminished according to the character of its dead load stress by an amount $\frac{S_s L}{E A}$ in inches; in which

S_s = Dead Load Stress (rocker removed).
L = Length of member in inches.
A = Section of member in sq. in.
E = Modulus of elasticity = 29,000,000 lbs. per sq. in.

Further, by means of a device for raising or lowering the anchor end, the meeting cantilever ends during erection will be adjusted to fit the length of the rocker, so that the latter will be under no stress from the action of dead load alone. Therefore, for dead load stresses, $S_r = 0$, and hence the dead load stresses are statically determinate. Their computation presents no special difficulty, though the repeated corrections of truss weights and panel-concentrations, and the re-drawing of stress diagrams, were somewhat tedious.

*This is not strictly true, since reversal of stress in any member of the truss affects the rocker stresses. The effect is small if the members subject to reversal have a small value of u.—Ed.

The chief theoretical interest attaches to the question of live load stresses.*

The action of the rockers, which is analogous to that of the end supports in a draw span, may be more clearly apprehended if reference be made to Fig. 4. Let E B and A D represent the two cantilever-ends at the middle of one of the river spans, in the positions which they take when under dead load alone. The arms have been adjusted so that the distance A B equals the length of the rocker, which, if placed in position, would not now be subjected to any stress. Suppose that, with rocker removed, the live load covers both cantilevers. The load on the left arm would cause B to descend to B', and that on the right would cause A to descend to A'; and since the two arms are not alike in all respects, the deflections A A' and B B' are unequal, hence A' B' may be more or less than A B, depending on the relative flexibility of the two arms. Let us assume that in the present instance B B' > A A', and hence A' B' > A B.

In order now to replace the rocker, thus reconnecting A' and B', these points must be brought closer together: that is, A' must be forced down and B' forced up, until the distance between their positions, A'' and B'', is equal to A B (if we assume the rocker to be rigid). The magnitudes of A' A'' and B' B'' will again depend upon the relative flexibility of the two arms. It is evident that the tendency of the arms to separate and return to their positions A' and B' is counteracted by the stress in the rocker, tension in the case assumed; and that the amount of this stress is the cause of a deflection A' A'' in one arm and B' B'' in the other.

Referring to Fig. 5, let A B C D represent diagrammatically one of the river spans, unloaded; A B_1 and D C_1 the forms which would be taken under a known system of loading, if B and C were unconnected. It is required now to find the value of the equal and opposite forces, which, when applied at B_1 and C_1, will cause those ends to come together at some point E: also the distances C_1E and B_1E. Let Δ_l and Δ_r denote the respective total deflections B B_1 and C C_1 of the left-hand and right-hand arms. Let δ_l and δ_r denote the respective deflections when a known load w is applied at B or C. Assume $\Delta_l > \Delta_r$.

Then an upward force xw at B_1 causes B_1 to rise a distance $x\,\delta_l$, and a downward force xw at C_1 causes C_1 to descend a distance $x\,\delta_r$. B_1 and C_1 come together when $B_1 E = x\,\delta_l$ and $C_1 E = x\,\delta_r$. That is, the respective displacements are directly proportional to δ_l and δ_r.

Therefore, $$\frac{C_1 E}{B_1 E} = \frac{\delta_r}{\delta_l}$$

Hence, $$\frac{C_1 B_1}{B_1 E} = \frac{\delta_l + \delta_r}{\delta_l}$$

Or $$B_1 E = (\Delta_l - \Delta_r)\frac{\delta_l}{\delta_l + \delta_r} \quad \ldots\ldots (2)$$

And $$C_1 E = (\Delta_l - \Delta_r)\frac{\delta_r}{\delta_l + \delta_r} \quad \ldots\ldots (3)$$

By the same principle we find, when load extends from A to B only, Fig. 6,

$$B_1 E = \Delta_l \frac{\delta_l}{\delta_l + \delta_r} \quad \ldots\ldots (4)$$

$$C E = \Delta_l \frac{\delta_r}{\delta_l + \delta_r} \quad \ldots\ldots (5)$$

And when load extends from C to D only, Fig. 7,

$$B E = \Delta_r \frac{\delta_l}{\delta_l + \delta_r} \quad \ldots\ldots (6)$$

$$C_1 E = \Delta_r \frac{\delta_r}{\delta_l + \delta_r} \quad \ldots\ldots (7)$$

Denoting reactions at B or C by R, using the minus sign (−) for an upward and the plus sign (+) for a downward reaction, when load is on A B the reaction at B_1 necessary to raise that end a distance $B_1 E$ is $\frac{B_1 E \times w}{\delta_l}$, and from Eq. (4)

$$R_1 = -\frac{\Delta_l w}{\delta_l + \delta_r} \quad \ldots\ldots (8)$$

When load is on C D reaction at B is similarly from Eq. (6):

$$R_2 = +\frac{B E \times w}{\delta_l} = +\frac{\Delta_r w}{\delta_l + \delta_r} \quad \ldots\ldots (9)$$

Again, from Equation (2), when load extends from A to D, the reaction at B is,

$$R_b = -\frac{B_1 E \times w}{\delta_l} = -\frac{(\Delta_l - \Delta_r)w}{\delta_l + \delta_r} \quad (10)$$

$$\therefore R_b = R_1 + R_2 \quad \ldots\ldots (11)$$

And the same is evident for reaction at C, which is for each case equal in magnitude and opposite in direction to that at B.

If, then, loading for example Div. 1, we find the rocker stress R_1 and the consequent stress S_{r1} due to R_1 in any member of the truss, and, loading Div. 2, we find the value of R_2 and stress S_{r2} for the same member, then, when the load extends over both Div. 1 and Div. 2, the

*The wind load is carried by a lateral system in the bottom chord. This system is of the same type as the main trusses. The wind pressure was assumed at 2,000 lbs. per lin. ft.

rocker stress is $R_1 + R_2$, and the stress in the member from rocker action is $S_{r1} + S_{r2}$, proper regard being paid to algebraic signs. In the same manner, if the load extends over three divisions,

$$R = R_1 + R_2 + R_3 \text{ and } S_r = S_{r1} + S_{r2} + S_{r3},$$

and likewise for any number of subdivisions, whether contiguous or not.

The effect of the rockers on truss-members included in Div. 4 requires special note. A load anywhere on the bridge causes deflection at both 37 and 91, and there are, in consequence, two stresses S_r to be calculated for all the members between points 57 and 75, for each of the seven cases of loading.

It is now necessary to investigate the effect of the elastic deformation of the rocker itself upon the reactions at 37 and 91.

Referring to Eq. (10),

$$\frac{(\Delta_1 - \Delta_r)\,w}{\delta_1 + \delta_r}$$

would be the value both of the stress in the rocker and the reaction at the end of the cantilever arm, if the rocker were rigid. Letting l represent the length of rocker in inches and a its section in sq. in., the above stress would cause a stretch q in the rocker which would allow B and C (Fig. 5) to separate slightly, and thus reduce the reaction. The value of this stretch is

$$q = \frac{(\Delta_1 - \Delta_r)\,w}{\delta_1 + \delta_r} \cdot \frac{l}{Ea}$$

and the reaction is therefore

$$\frac{(\Delta_1 - \Delta_r)\,w}{\delta_1 + \delta_r} - \frac{q\,w}{\delta_1 + \delta_r} = \frac{(\Delta_1 - \Delta_r)\,w}{\delta_1 + \delta_r}\left[1 - \frac{l\,w}{Ea\,(\delta_1 + \delta_r)}\right] \quad \ldots (12)$$

By the introduction of the values of the known constants, the last factor becomes 0.9937 at 37 and 0.9928 at 91. Taking the average of these:

$$\text{Reaction} = \pm\ 0.9933\ \frac{(\Delta_1 - \Delta_r)\,w}{\delta_1 + \delta_r} \quad \ldots (13)$$

And the same numerical co-efficient applied to the rocker stress for any case of loading, as above calculated, gives the true rocker stress.

The process of finding the live load stresses may then be summarized as follows:

Assume the rockers removed, and obtain the static stresses S_s.

Denoting the cantilever ends by 37w, 37e, 91w and 91e, find the stress or co-efficient u for each member, due to a load of unity at each of those points.

Let Δ_{37w} = Deflection of 37_w due to the load producing S_s

Δ_{37e} " 37_e " " "

Δ_{91w} " 91_w " " "

Δ_{91e} " 91_e " " "

δ_{37w} " 37_w due to load of 1,000 lbs. at 37_w

δ_{37e} " 37_e " " " 37_e

δ_{91w} " 91_w " " " 91_w

δ_{91e} " 91_e " " " 91_e

d_{37} " 37_e " " " 91_w

d_{91} " 91_w " " " 37_e

u_{37} and u_{91} = Coefficients for load unity at 37 or 91.

E = Modulus of elasticity = 29,000,000 lbs. per sq. in.

L = Length of member in inches.

A = Area of cross-section of member in sq. ins.

Then

$$\Delta_{37w} = \Sigma\ \frac{S_s\,u_{37}\,L}{EA} \quad \ldots (14)$$

and similarly for Δ_{37e}, etc.

$$\delta_{37w} = 1000\ \Sigma\ \frac{(u_{37})^2 L}{EA} \quad \ldots (15)$$

and similarly for δ_{37e}, etc.

$$d_{37} = d_{91} = 1000\ \Sigma\ \frac{(u_{37})\,(u_{91})\,L}{EA} \quad \ldots (16)$$

By means of these equations we find:

When full load is on Div. 1, Δ_{37w} = — 4.140 ins.

" " 2, Δ_{37w} = + 22.359 ins.

" " 3, Δ_{37w} = + 25.734 ins. and Δ_{91w} = + 3.832 ins.

" " 4, Δ_{37e} = — 5.508 ins. and Δ_{91e} = — 4.642 ins.

" " 5, Δ_{37e} = + 3.009 ins. and Δ_{91w} = + 16.644 ins.

" " 6, Δ_{91e} = + 18.473 ins.

" " 7, Δ_{91e} = — 5.053 ins.

and δ_{37w} = 0.03077 ins.

δ_{37e} = 0.03465 ins.

δ_{91w} = 0.02779 ins.

δ_{91e} = 0.02988 ins.

$d_{37} = d_{91}$ = 0.00326 ins.

The minus sign indicates upward deflection.

The stresses in the rockers, derived from these deflections, are given below in 1,000-lb. units. The sign + indicates tension and — indicates compression.

Rocker Stresses, Blackwell's Island Bridge.
In units of 1,000 lbs.

Portion Loaded.	Rocker 37.	Rocker 91.
Div. 1	— 63.3	+ 3.57
" 2	+ 342.0	— 19.3
" 3	— 394.0	— 66.3
" 4	+ 84.3	+ 80.3
" 5	— 46.1	— 288.5
" 6	— 15.95	+ 320.0
" 7	+ 4.37	— 87.5

The stress S_r in a member for any case of loading is obtained by multiplying the stress in the rocker, for that position of the load, by 0.9933 and by the co-efficient u for that member; and the true stress by combining this product with S_s, already known, as in Eq. (1).

We thus have for each position of load what may be called the partial stresses. The greatest tension and compression from a load extending over one, two or more contiguous subdivisions, obtained by the algebraic addition of the partial stresses for each member, are then tabulated. Both tensile and compressive maxima are necessary in order that the table may reveal by inspection every reversal of dead load stress. The following specimen tabulation indicates a convenient arrangement for this work:

The stresses in secondary members are easily found by loading each panel separately. Pier reactions are found by a process exactly similar to that used in obtaining stresses in main numbers.

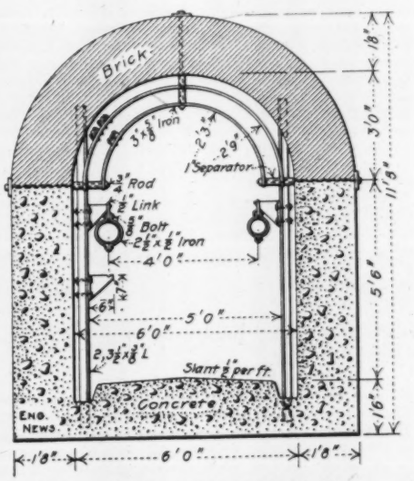
The number of approximations necessary is not so great as would at first appear. For if the tentative areas used in calculating deflections were too great or too small in a constant ratio as compared with the areas required by the resulting stresses, while the quantities Δ, δ and d would be too small or too great in the same proportion, yet the ratios of these deflections, on which depend the rocker stresses, would be correct; and although many trials were made in the case of dead load stresses, but two were found necessary to obtain the stresses in the rockers.

(A brief abstract of the discussion on this paper will be found in the column "Engineering Societies," on p. 178 of this issue.)

A SHORT SUBWAY FOR PIPES AND WIRES.

By John D. Adams.*

The transmission of steam for any great distance with any degree of economy is not an easy matter. Particularly is this the case in the cold weather. To facilitate the transmission of steam for heating and drying apparatus to a distance of



Section of Subway for Pipe and Wires.

500 ft., the tunnel shown herewith was constructed. At intervals of 16 ft. angle irons are set into the tunnel, as shown in the section, for the support of the piping. The pipes are held by a split band of 2½ × ½-in. iron, and a link of ½-in. iron, which hangs on an iron bracket made from ¼-in. plate. This arrangement permits placing the pipe at any convenient height from the bottom of the tunnel, and also allows considerable play for expansion and contraction. The whole is supported on a series of concentric semicircular bands of 3 × ⅝-in. iron held to the arch by ¾-in. rods and gas pipe separators. The porcelain cleats were bolted with ⅝-in. bolts to the iron bands.

The tunnel has several manholes located at convenient points and has proved very efficient in every way. It was built in 1903 for Parke, Davis & Co., Detroit, Mich., with C. R. Smith as engineer.

*Phoenix, Ariz.

METHOD OF ASSESSING LONGER SIDE OF CORNER LOTS FOR PAVING IN 16 NEW JERSEY CITIES.

The following statements regarding pavement assessments for corner lots in New Jersey were furnished to Mr. Andrew J. Gavett, City Surveyor and Street Commissioner of Plainfield, N. J., by the city engineers named. We are indebted to Mr. Gavett for a blue print giving the information.

Long Branch; J. W. Seaman.—Full assessment made on both fronts.

New Brunswick; Asher Atkinson.—Full assessment made on both fronts.

Camden; L. E. Farnham.—Full assessment made on both fronts, but ¼ to ½ of total cost, without intersections, sometimes assessed on city.

Atlantic City; J. W. Hackney.—Full assessment made on both fronts.

Paterson: H. J. Harder.—Full assessment made on both fronts.

Plainfield; Andrew J. Gavett.—Full assessment made on both fronts (city pays 20% to 33%); commissioners may make allowance on future work.

Elizabeth; W. H. Luster, Jr.—On side first paved, full assessment. On other side, a concession of 20% to 30%. Depth also considered.

Jersey City; C. A. Van Keuren.—On lots 25 × 100 ft., 100 ft. frontage, assessed about 70%. Intersections assessed to block centers.

Perth Amboy; Forrest L. Smith.—Assessment made according to benefits received. *Triangular lots assessed ⅓ of each frontage; ⅔ of side assessed where front is 50 ft. or less.

Newark; Ernest Adam.—65% of side generally assessed.

East Orange; W. H. V. Reimer.—*50% reduction on side, up to depth of 100 ft. only, after one side has paid full assessment.

West Hoboken; Robert Gaw.—*50% reduction on side, if 100 ft. deep.

Bayonne; Emmett Smith.—50% reduction on side.

Trenton; John P. Dullard, Comr.—Assessments made on basis of benefits conferred. *If less than 100 ft. deep, charge for ½ frontage; if more than 100 ft. deep, deduct 50 ft.

Orange; Fred. T. Crane.—A small allowance, not uniform, made on side of corner lots.

Passaic; Colin R. Wire.—Deduct for lots under 80 ft. deep, 1% to 75%, as per blue-print diagram showing curve for assessment of shallow lots.

Morristown; Arthur S. Pierson.—Question has not been brought up.

Montclair; Frank W. Crane.—All paving done by general taxation, a certain sum being set aside each year.

*Stating the general basis of assessment.

THE TOLEDO RAILWAY & TERMINAL CO. owns a new belt line 28.75 miles long around the city of Toledo, O., with a 2½-mile branch to a new passenger and freight terminal station. The belt line has about 15 connections with steam railways and four connections with electric interurban railways, all these connections being equipped with interlocking plants. The terminal station has a headhouse 200 ft. long, with two parallel trainsheds, each covering five tracks. The engine houses, coaling station and repair shop are located at the connection of the terminal branch with the belt line. There are two bridges over the Maumee River. One of these has a central draw span of 253 ft., approached on both sides by four 145-ft. deck truss spans, and a 40-ft. girder span, the total length of the bridge being 1,493 ft. The other bridge has a 358-ft. draw span, approached on one side by three spans of 208 ft., and on the other side by two spans of 156 ft.; including the two trestle approaches the length of this bridge is 3,036 ft. The railway was built to afford terminal facilities and to improve the interchange of passenger and freight traffic between the several railways with which it connects. It will also assist in the industrial development of the city, as it serves large areas of vacant land adapted for manufacturing establishments. Mr. T. F. Whittelsey is General Manager, and has had much to do with the promotion and construction of this new line.

Blackwell's Island Bridge. Form of Tabulation of Stresses. L L Stresses are for 4,000 lbs. per ft. per Truss. Tension + Compression — 1,000-lb. units.

	Lower Chord. Stress due to L L on—							—Max. for Contin.—		D L Stress.
Mem.	Div. 1.	Div. 2.	Div. 3.	Div. 4.	Div. 5.	Div. 6.	Div. 7.			
1—3	+ 778	— 1,003	— 469	+ 100	— 54	— 19	+ 5	+ 778	— 1,472	— 1,000
3—5	+ 1,182	— 1,768	— 831	+ 178	— 96	— 34	+ 9	+ 1,182	— 2,599	— 2,390
5—7	+ 1,340	— 2,410	— 1,130	+ 242	— 131	— 46	+ 12	+ 1,340	— 3,540	— 4,000

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We print on another page of this issue a brief paper advocating the use of ballasted floors for railway bridges, with granulated blast furnace slag as the ballast. A very important advantage of this material, as pointed out by the author, is its very light weight, only 35 lbs. per cu. ft. after packing and settling. This means, of course, a very much smaller dead load on the bridge than is involved in the use of a broken stone ballasted floor.

A question which will be raised in the minds of many engineers, we are sure, is whether slag may not cause corrosion of the iron plates with which it is in contact. Slag is a material very variable in its chemical constituents, and from certain furnaces working on certain ores and coke, it contains, if we mistake not, unstable sulphur compounds which when exposed to moisture are likely to cause corrosion of adjacent iron or steel. We shall be glad to hear from any of our readers who can give authentic information on this matter.

In this connection, too, it should be said that the life of solid floor bridges ballasted with clean broken stone is still to be determined. The wash from ashes dropped from locomotives and the drippings from refrigerator cars are certainly very corrosive, and the ballast undoubtedly tends to hold such corrosive liquids in close contact with the thin steel plates forming the floor. Can the paint or asphalt or other protection applied to these plates when the floor is built protect it long against such destructive agents? That is the question which appeals to many engineers when considering the question of ballasted bridge floors, and it is this as much as anything, we believe, that is limiting the use of the solid ballast floors that were so highly advocated ten years ago. In place of the trough and buckle-plate floors, the present tendency, we believe, is toward the use of floors in which the steel is protected by concrete, a number of which are illustrated in this issue.

One of the largest water filtration plants in the world and, next to the Torresdale plant now being built for Philadelphia, the largest in the United States, will soon be put under construction at Pittsburg, Pa. A note on the proposed plant appeared in our issue of Feb. 2. The work is now being advertised in ten separate contracts, the specifications for which fill about two thousand printed octavo pages, accompanied by hundreds of sheets of blue-prints. Rarely does one see such detailed contract drawings as have been prepared in this case, and seldom does a city invite bids on so many important contracts at one time. There will be large settling reservoirs, 46 one-acre covered filter beds, covered clear water reservoirs, large conduits and pumping stations. Notable features of the filters will be the placing of all the main filter piping connections in galleries between rows of filter beds, provisions for taking dirty sand from any bed, washing it and placing it on any other bed without storage, a central administration building with laboratories, and ventilation of the filters and filter galleries when needed. Alternative proposals are invited on scraping the filters and replacing the washed sand by machine and hand.

Perhaps the most notable of all the contract requirements for the Pittsburg filter contracts are those relating to the sanitation of the contractor's camp and the health of the workmen. Laborers' quarters must give at least 500 cu. ft. of air space per sleeper, have tight floors at least 1 ft. above the ground, have for each camp a separate building for a wash house or laundry, and another for a kitchen or cook house. No stable shall be nearer than 150 ft. to any of the buildings just named. Pure water approved by the city authorities must be supplied to the workmen, all garbage must be stored in "tight" receptacles and burned without nuisance once in 24 hours. Water closets must be provided for all laborers, subject in all particulars to the control of the city authorities, and must be connected with "tight" septic tanks, effluent from which must be "reasonably clear, colorless, free from disagreeable odor and entirely unobjectionable to run out to a water course." Medical supervision and care of the workmen, the removal of men suffering with communicable diseases and the employment of no unvaccinated men is also required. These sanitary regulations are highly commendable, and for the interest of the contractor as well as the city. The rules for water supply, garbage and sewage disposal, if effectively carried out, will reduce the dangers from typhoid fever, both to the workmen and to the city water consumers after the reservoirs and filters are put in use. Mr. E. W. Bigelow, M. Am. Soc. C. E., is Director of Public Works of Pittsburg, and Mr. Morris Knowles is Chief Engineer of the Bureau of Filtration.

THE DESIGN OF THE BLACKWELL'S ISLAND BRIDGE.

Now that the longest span cantilever bridge ever undertaken in the United States is under construction—a bridge which will be perhaps the heaviest per foot run ever built of any type, which is wholly novel in its general type, as far as America is concerned, and which will be the first in whose make-up nickel steel holds an important place—the description of the stress analysis as presented elsewhere in this issue, will doubtless arouse much interest among bridge engineers. There are many points of interest in the design of this bridge, and some of them are points on which there are strong differences of opinion between engineers.

Historically, the Blackwell's Island bridge takes precedence in interest over the noted North River bridge proposition, and even over the much more famous Brooklyn bridge. For, plans to bridge the East River at Blackwell's Island have been afloat for at least seventy years; the existence of an island dividing the channel into two parts has long made this location a most attractive one for a bridge connecting Manhattan Island with Long Island. We have before us a print dated 1837, showing a proposed three-span suspension bridge at Blackwell's Island, accompanied by a description from which we quote as follows:

> Mr. Graves' plan for an iron hanging bridge over the east and west channels of the East River, from between 65th and 75th Sts. on the city of New York side, across the northern part of Blackwell's island to a feasible point on Long Island opposite * * * The bridge to have three openings of seven hundred feet each between the points of suspension, * * * suspended from four catenarian lines of malleable iron chains or cables (of four cables each) by perpendicular lines of iron rods * * *.

A hanging-bridge upon the construction as above roughly suggested, it is ascertained from experiments made, would have a surplus of upward of twelve hundred tons remaining, denoting the strength of the bridge; a weight that beyond probability would never be upon the bridge at one point of time. The expense of constructing this bridge would vary from five hundred to eight hundred thousand dollars.

During the past twenty or thirty years there has always been some plan before the public for a bridge in this locality. But in these many years the importance of the crossing has ever increased, as the tributary population and the probable traffic has grown larger and larger. The early highway bridge scheme just referred to, with its 1,200 tons ultimate live-load capacity, has grown to a multiple street-railway and rapid-transit railway bridge whose ultimate live-load capacity is perhaps a hundred times as great.

In the earliest plans the suspension type of bridge was, of course, the only one in question. More recently cantilever construction came into consideration, and for two decades has been the more prominent. The final design, worked out about three years ago, departs from all previous proposals by providing for a truss which, though of cantilever type, is different from all American cantilevers and classes statically with "constrained" or continuous girders. The suspended span is omitted, avowedly for æsthetic reasons and for ease in erection, and the cantilever arms continue to the middle of the span where they are held together by a pendulum arm or rocker.

The adoption of this "constrained" form of truss is one of the main points upon which difference of opinion appears. So far as precedent goes, everything favors the pure cantilever type built with suspended span. All the great cantilever bridges of the world are of this type, including the Forth bridge which exceeds the span proposed for this structure and the Quebec bridge now under construction with a span greater even than the Forth bridge. Therefore the burden of proof lies on the advocates of the constrained type of cantilever.

Briefly, they argue that the bridge will be more beautiful, can be more cheaply erected, and will prove more rigid, than a pure cantilever. The suspended span is considered to introduce difficulties in suiting æsthetic requirements, although recent large bridges of the pure cantilever type both in America and in Europe show very satisfactory solutions of the æsthetic problem. It is held that the suspended span, if of reasonable length, will be so heavy, on account of the high live-load, that the erection stresses will wholly neutralize the economy of the pure cantilever type. It is considered, further, that in the bridge as actually designed, the two half spans mutually support each other, for which reason the constrained cantilever should be more rigid than the other form.

In reference to the latter argument, it is proper to observe that large city bridges carrying heavy traffic, without great train-concentrations, are very rarely loaded other than with uniform full distribution. Under such loading the constrained cantilever has a sharp peak of deflection at the middle, while the pure cantilever is horizontal at the middle due to the bending of the suspended span; the latter should therefore prove stiffer under full load. Concentrated partial loading is of such rare probability in this as in any large highway bridge that rigidity under such loading is of quite secondary importance. Yet it is not necessarily true that the constrained cantilever is the more rigid under such load, as this depends wholly on the individual case.

The third argument, that of erection, is one for individual consideration. It is certainly not self evident that a suspended span would differ appreciably in weight from the corresponding end sections of the present cantilever arms; the erection argument depends principally, therefore, on the supposed difficulty of taking care of the reversed stresses in the suspended span during erection.

Speaking of reversed stresses brings to mind the fact that the Blackwell's Island bridge, a constrained structure, is pin-connected throughout. It is known that in a constrained structure of any kind the inelastic deformation resulting from play in pin-holes may vitiate the calculated stresses. This applies, of course, only when one or more members of the structure are subject to reversal

of stress; but when reversal occurs, its effects (in respect to changing the stresses) are not restricted to the members suffering reversal but extend to all members of the structure, and they are, moreover, not at all easy to compute. This fact is a strong reason why statically indeterminate (constrained) structures, when there is possibility of stress reversal in any of the members, should have riveted connections throughout, a reason which is almost universally appreciated in its application to two-hinged and continuous arches. In the case of structures which are much more economically built with pin connections, as in the case of the Blackwell's Island bridge, the same reason operates to make a constrained structure undesirable, at any rate when partial live-loading is of importance. This argument, together with the more familiar argument of settlement of supports, is therefore a distinct reason for preferring the pure cantilever type to the constrained cantilever.

In the stress calculation described in a paper of Mr. R. C. Strachan on another page of this issue—whose simple and clear exposition of the work we commend to students of modern bridge design—the effect of pin-hole play is passed over rather lightly with the statement that it may be neglected. As the calculated results show that under certain conditions of loading some members experience reversal of stress, this statement may be questioned by some. Accurate calculation of the effect of pin-hole slack in such structures is not easy, however, and requires an assumption as to the amount of the play at each pin. In view of the fact that the live load on the Blackwell's Island bridge will probably never be very far from uniform in distribution, and since no reversal of stress can occur unless the live-load be confined to a small part of the bridge, we believe the neglect of pin-hole play is justified.

In regard to the stress-calculation itself, we take space to refer to only two points. The first is the simple and systematic arrangement of work which resulted from the choice of the rockers as the "redundant" members. In any structure which, like the present one, has two points of constraint, almost any two members may be selected as the "redundant" members from which the constraint stresses are calculated. But the ease of the work, the possibility of systematic arrangement, and the chances for inaccuracy, are much affected by the choice of the two members in question. Any two of the supports, or almost any two main truss members, might have been considered as the redundant ones. In the present case the choice of the two mid-span connectors suggested itself rather naturally; the advantages thereby secured, as against the choice of any other members will be best appreciated by those who have gone through a similar calculation. In many cases of constrained frames, however, the proper choice is by no means so evident, and it is worth while to consider most carefully before beginning work, the advantages and disadvantages of each particular selection of redundant members.

The second detail of the stress-calculation to which we wish to draw attention is the assumption as to live loading. It is proper to note that much discussion arose, at the time the bridge was designed, as to the capacity for which the bridge should be designed. A special commission of three engineers was finally appointed to fix upon capacity and consequently live load. Their recommendation of 16,000 lbs. per lineal foot of bridge was used for the design. In spite of this high loading, there are already predictions by competent authorities that the bridge will very soon be inadequate to handle the traffic offering. But the assumption as to amount of live load is less interesting here than the assumption as to its distribution. It will be noted that the "probable" maximum live load was taken as half the amount fixed by the expert commission as "possible"; the other half, therefore, goes into the factor of safety. Evidently assumptions of this kind require the greatest care and best judgment of the conditions of the case. The same applies to the further assumptions (1) that no *two* isolated sections of live-load can occur on the bridge, and (2) that no sections of live-load shorter than one main division of the bridge need be considered. The influence and field of such assumptions in the design of extremely large bridges will repay consideration by bridge engineers; they are assumptions of a kind to be separately fixed upon for each individual case, and not to be transferred from one case to another without detailed reconsideration of the local conditions.

THE IMPROVEMENT OF RAILWAY PASSENGER STATIONS AND TERMINALS.

Within the past dozen years a large number of new railway passenger stations have been built in the larger cities of this country. Among the notable ones we may mention those in Boston, Philadelphia, St. Louis, Omaha, Albany, Jersey City and Pittsburg. At the present time, however, a larger amount of work appears to be in prospect in the construction of great new passenger stations in large cities than has ever been undertaken. In New York City two of the largest and finest railway passenger stations in the world are to be built by the Vanderbilt and the Pennsylvania systems. In Washington a splendid union station which will be a monument of architectural excellence is already under way. In Buffalo the railways and the city authorities have agreed upon a location for a great new union station.

The largest project of this sort now proposed, however, is a rearrangement of the railway passenger terminals of Chicago. That city is now served by 22 trunk lines, which have six terminal stations scattered in different parts of the city, necessitating a large amount of transfer of through passengers from each station to all the others. The Delano plan, which is described elsewhere in this issue, proposes to retain the same number of stations, under practically the same ownership and use as at present, but to replace the present scattered stations (some of which are old and inadequate) by six large new stations to be erected side by side on property already owned by the various railways. We believe that this is the first time that such a plan has been suggested for any city, comprising as it does a concentration of terminal facilities without the joint ownership and use involved in the establishment of a single union station. The Torrance plan of 1891 and the Sattley plan of 1901 each proposed a Chicago union station for all the railways; the former had to provide for only ten trunk lines, while the latter provided for 22 lines, the same as in the more recent Delano plan. It was estimated that the Sattley station would have to provide for some 1,050 trains daily, a large proportion of these being in suburban service.

That these great new stations, completed, under construction and projected, are only a beginning in the work of reconstructing the railway passenger terminals of this country, everyone familiar with the situation must concede. In probably the majority of American cities, notwithstanding the work of station building done during the past dozen years, the existing passenger stations are old buildings, dingy in appearance, more or less unsanitary, and inadequate to properly care for the traffic. In cities where these conditions exist there is from time to time a desire (voiced through the daily press and through local commercial organizations) for larger, better and more attractive stations. Wonder is frequently expressed that the railway companies do not take the initiative and erect handsome stations with all modern conveniences, and they are frequently censured for not taking such action. A railway company, however, has to consider this matter from the financial standpoint, and as long as the old station can be made to handle the traffic, and there is no absolute public outcry against the accommodation furnished, the expensive work of rebuilding the terminal is apt to be put off as long as possible. Nor is this attitude an unreasonable one. It can hardly be maintained that the building of new passenger stations has much influence in stimulating the volume of traffic, and there can be, therefore, little direct return on the investment. It is evident, therefore, that heavy expenditures for a new station can hardly be justified as long as the old station can furnish decent facilities, and the traveling public is fairly well satisfied.

A mistake which is sometimes made by railway companies, however, is to allow an old station to fall into a somewhat dilapidated condition, and to give it less care than would be given to a new station, whereas an old station really needs much more attention to keep it in proper condition. Dirt and dilapidation, defective plumbing (which is very frequently in evidence in such cases), and a general air of neglect are liable to cause complaint and arouse a public demand for a new station. In many cases a reasonable expenditure in repairs and decoration, with attention to heating, lighting and ventilation, and proper attendance, would so far improve conditions that the erection of a new station could be postponed for some years.

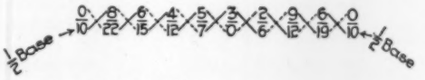
An important point to be considered in planning the improvement of railway passenger stations is that such improvements should generally be made in cooperation with the municipality. In most American cities the railways reach their stations by running through streets and at grade. These conditions were established when the railway was originally built and often when the city itself was a small town. The time to change these conditions is when a new passenger station is planned. Often the promise of a fine new station will influence municipal cooperation in the removal of grade crossings, the widening of street approaches and the improvement of the lands adjacent to the railway entrance to a city. If one were to judge of our American cities by their appearance as one enters them by rail, what a conglomeration of ash heaps, dilapidated shanties, advertising signs and ragged dirt banks they would appear to be. We put up with these things because we have become accustomed to them; but as public attention is more and more concentrated on the work of municipal improvement, the demand becomes greater that such offences against good taste and good sanitation shall be wiped out.

Why should a city expect a railway company to build a fine new passenger station when the city itself allows the approaches to continue as ill-paved and dirty streets, and does nothing to improve the region adjacent to the railway terminals?

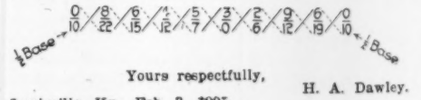
LETTERS TO THE EDITOR.

Calculating Cross-Section Areas: Correction.

Sir: In the method given for calculating cross-section area in your issue of Feb. 2, 1905, the section should be written thus:



and not as printed, thus:



Yours respectfully,

H. A. Dawley.

Louisville, Ky., Feb. 3, 1905.

Comparative Cost of Plain and Reinforced Concrere Retaining Walls.

Sir: I was much interested in the article of Mr. F. F. Sinks regarding the "Analysis and Design of a Reinforced Concrete Retaining Wall," which appeared in your issue of Jan. 5, and I agree with him in all the points requisite to be observed in such a design, except where he says: "The volume of the concrete shall not be reduced to such an extent that the cost per yard of machine mixing, handling and placing of concrete will exceed that for a plain wall," for it would certainly be good practice to reduce the quantity, say, 50%, when it can be done without reducing stability, although the cost of the concrete may be considerably more per yard. There would, however, be but little increase when the forms are kept as simple as for plain walls, as Mr. Sinks suggests.

Possibly the following description of a reinforced wall erected at Lebanon, O., last fall, which shows much greater economy than the design given by Mr. Sinks, when compared with a plain concrete wall of the same quality and stability, will be of interest to your readers. The wall was designed according to Trautwine's formula for earth pressure. The fill was taken at 100 lbs. per cu. ft., and

the concrete at 130 lbs. per cu. ft. The section is shown in Fig.

The weight of the earth vertically above the heel is considered as a part of the wall in figuring the stability of the wall against overturning, for this weight on the heel acts truly as a force to prevent overturning when it is considered of earth as if it were composed of stone

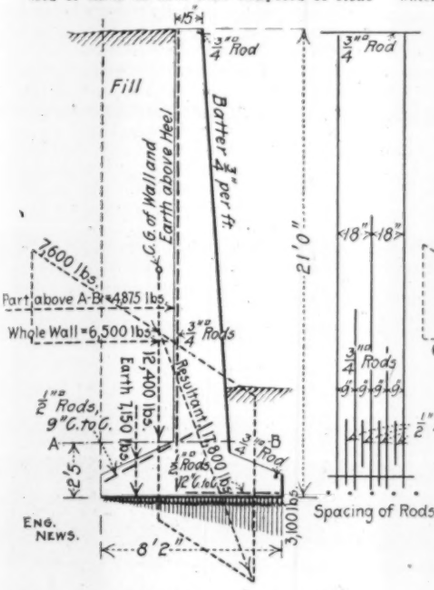


Fig. 1.

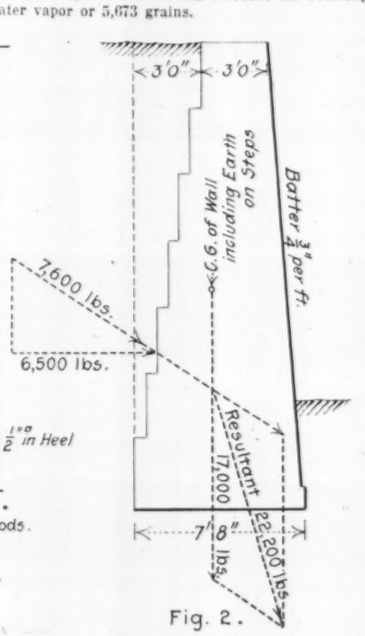


Fig. 2.

or concrete. The resultant was made to cut the base one-third from the toe.

The toe was made rather long in proportion to the heel, in order to save excavation and fill. There being natural rock ledges in front of the toe, there was no danger of the wall sliding forward on its base. It was not deemed necessary to provide for any surcharge. The tensile strength of concrete was not taken into consideration. For reinforcement Ransome twisted bars of high elastic limit were used, the allowable stress limit being 16,000 lbs. This gives a factor of four for ultimate strength, and a little more than a factor of three for elastic limit, which were deemed ample for such a construction as this from the fact that the load which it is figured to stand is considered the maximum that can occur, and also because the load being carried by numerous small independent members makes the structure much safer than if it were carried by a few large members, for a defect and failure in one simply lowers the factor of safety a small per cent. The part above the line A B was figured as a cantilever. Thacher's formula was used to obtain the amount of steel. The heel and toe were also figured in the same manner for the stresses that come on them; that is, for the weight of the fill vertically above the heel and the pressure of the earth upward against the toe. Only two longitudinal rods were used, one near the top and one near the toe.

Fig. 2 shows a section of a plain concrete wall of the shape usually employed in this vicinity. The data used were the same as those used for Fig. 1. Trautwine's formula was used, considering the fill vertically above the steps on the back of wall as a part of the wall. The resultant cuts the base at one-third from the toe, the same as for Fig. 1.

As to the comparative cost of the two designs, we find that the reinforced wall of the section shown in Fig. 1, 185 ft. long, cost $13 per lin. ft. On the same day that the contract for the above wall was let, the same contractor bid on a plain concrete wall for the same place with a section similar to Fig. 2 (except it was not quite so thick) at the rate of $5.40 per cu. yd., including excavation, casing, etc. The extra thickness of the wall shown in Fig. 2 over the one bid on, would not decrease the cost per yard more than, say, 10 cts. The wall shown in Fig. 2 contains 4 cu. yds. per lin. ft., which, at $5.30, amounts to $21.20, the plain concrete wall thus costing $8.20, or 63% more than the reinforced wall.

Very truly, Frank A. Bone.

2126 St. James Ave., Cincinnati, Ohio, Jan. 19, 1905.

Some Elementary Facts Relating to Hygrometry.

Sir: As the subject of hygrometry has become prominent of late through the publication of Mr. Gayley's paper on dry air for blast furnaces, and the discussion in your journal some months ago on moisture in the air of dwelling houses, the following statement of some simple facts in relation to hygrometry may interest some of your readers:

One pound of saturated vapor of water occupies a given space at a given temperature regardless of whether the same space is also occupied by another gas, or is occupied by the water vapor alone. Thus one pound of water vapor at the point of saturation occupies at 60° F. a volume of 1,234 cu. ft. and will exert a pressure of .2545 lb. per sq. in. Under the same conditions a volume of 1 cu. ft. of space will contain .0008104 lb. avoirdupois of water vapor or 5,673 grains.

If, however, this vapor is heated beyond the point of saturation it will change its pressure and volume according to the law $\frac{p' v'}{T'} = \frac{p'' v''}{T''}$

If now without increasing the absolute quantity of moisture and assuming the vapor pressure constant, it is heated to 100° F. it will expand and one pound will occupy a space

$$V'' = \frac{p' v' T''}{T' p''} = V' \left(\frac{T''}{T'}\right) = 1{,}234 \times \left(\frac{560.7}{520.7}\right) = 1{,}328.8$$

And the weight of water vapor in 1 cu. ft. of space will be $\frac{1}{1{,}328.8}$ = .0007526 lb. avoirdupois or 5.268 grains.

At the point of saturation, however, 1 lb. of water vapor at 100° F. will occupy a space of 354 cu. ft. and the weight of vapor contained in a cu. ft. of space will be .002824 lb. avoirdupois or 19.768 grains.

The relative humidity under the assumed condition is $\frac{5.268}{19.768} = 26.65\%$.

In other words, the space occupied by the atmosphere contains 26.65% of the weight of water vapor which it is capable of containing under the assumed temperature.

The dew point is 57.5° F. because at that temperature the vapor in the air would come to the point of saturation and any further reduction of temperature would cause a deposition of moisture.

If the temperature of the air is 100° F. and the relative humidity is 50% the space occupied by the atmosphere contains half as much vapor by weight as it is capable of containing at that temperature. Now the specific volume is $\frac{1}{\text{density}}$ so that the volume of the vapor is twice what it would be at the point of saturation. But the pressure varies inversely as the volume, so that the relative humidity is the same as the ratio of the vapor pressure actually exerted to the vapor pressure at the point of saturation.

In other words, if the relative humidity is 50%, the relative vapor pressure is 50%, the relative vapor volume is 200%, and the relative vapor weight is 50%, all based on the values at the point of saturation for the temperature.

Lane Johnson.

Pueblo, Colo., Dec. 14, 1904.

Notes and Queries.

The erecting shop and crane girders of reinforced concrete, illustrated on p. 112 of our issue of Feb. 2, were built for the Ingersoll Milling Machine Co., of Rockford, Ill., and the designs for the building were prepared for the owners by Mr. Wm. W. Crehore, M. Am. Soc. C. E., of 116 Nassau St., New York City.

In our issue of Jan. 19, p. 77, reference was made to Ex. Doc. No. 78, H. R. 42d Congress, 2d Session, relating to data on bear-trap dams. The reference was in error, and should have read 43d Congress.

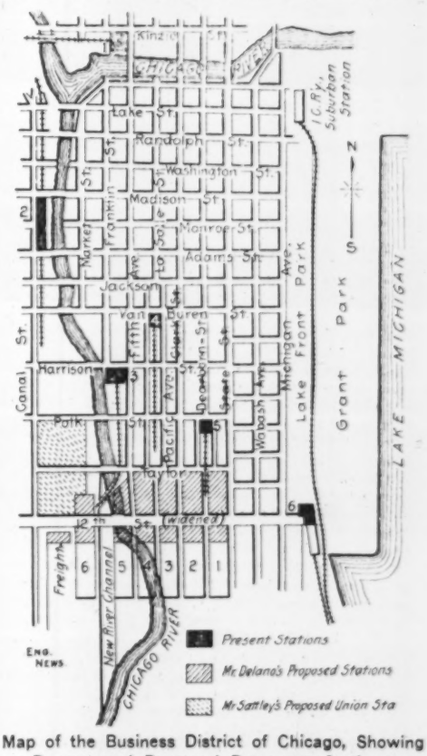
In our issue of Feb. 2 mention was made of the Austin Excavator which was used on Sewerage and Drainage Systems of Wheaton, Ill. We are informed that this excavator is now called the Chicago Sewer Excavator. In a foot note reference was made to our issue of Sept. 19, 1901, for a description of this machine, and, through an oversight, no reference was made to our issue of Dec. 24, 1903, which contains a more detailed description of the machine.

S. P. J., writes: An author in your issue of Feb. 2, in describing the suspension bridge failure at Charleston, W. Va., states that three double and two single teams make eight horses. Is his arithmetic or his interpretation of Webster's at fault?

Neither his arithmetic or his grammar was at fault. The word "team" in different parts of the United States has different meanings. In some sections "team" is never used except to denote two or more horses, mules or other animals harnessed together. In New England and in some other sections "a single team" means one horse and the vehicle which he draws. The Century Dictionary states that this use of the word team has been embodied in the statutes of certain states where a single team, meaning one horse with a vehicle, harness, etc., is exempt from attachment for debt.

PROPOSED PASSENGER TERMINAL SYSTEM FOR CHICAGO.

The city of Chicago has six passenger terminal stations for the 22 trunk lines of railway entering the city, but the terminal facilities are not equal to the requirements of the railways or the public. Most of these stations are located in unattractive and congested districts, approached by narrow and dirty streets, and having very indifferent facilities of access from and to different parts of the city. Their positions necessitate a tedious and cumbersome transfer of a large proportion of the through passengers by means of omnibuses, cabs and street cars, as well as the transfer of much baggage, mail and express matter. Several of the stations have insufficient capacity or accommodation for their traffic, but are



Map of the Business District of Chicago, Showing Present and Proposed Passenger Stations.

1. C. & N. W.
2. C. M. & St. Paul.; Penna. etc.
3. B. & O. & Chic. Term. Trans., etc.
4. C., R. I. & Pac., Lake Shore, etc.
5. Erie, Wabash, Grand Trunk, etc.
6. Ill. Cent., Mich. Cent., etc.

so situated that they cannot well be enlarged. The establishment of a single union station has several times been suggested, and in 1901 a scheme of this kind was worked out by Mr. R. C. Sattley, Division Engineer of Bridges and Buildings of the Chicago & Northwestern Ry., and was

described by him in a paper before the Western Society of Engineers (Engineering News, May 30, 1901). Another project has recently been proposed by Mr. F. A. Delano, M. Am. Soc. C. E., until recently General Manager of the Chicago, Burlington & Quincy Ry., and has been discussed at a public meeting of the City Club. Instead of a single union station, this plan provides for six stations adjacent to each other, and forming part of a plan for a general improvement of surroundings and approaches.

The site proposed is on 12th St. (or possibly Taylor St., 800 ft. farther north), from State St. west to the river, the sixth passenger terminal and a large freight station being on the west side of the river. In both cases the railways already own all the property between State St. and the river, and most of the property between the river and Canal St. The river would be straightened and improved where it passes through the railway property. The fact that practically all the property required is already owned by the railway companies makes the project a practicable one if the railways can be induced to take it up; there is the further advantage that the existing improvements upon this property are not of great value and could be readily replaced elsewhere. The street on which the railways front would be made 150 to 200 ft. wide, and elevated to the level of the present 12th St. viaduct crossing the tracks; it would be provided with an elevated railway, electric car lines and driveways so as to be easily accessible from transportation lines serving all parts of the city.

The plan does not require its immediate adoption by all the railways concerned, as some of them could continue to use their present terminals until such time as they should consider it desirable to use the new terminal. The heavy suburban traffic of the Illinois Central R. R. and the Chicago & Northwestern Ry. might be operated as at present, but while the former road has very convenient local stations for this traffic, the terminal of the latter road is very inconveniently located for suburban passengers. The plan further contemplates large office buildings to be built by the railways on the north side of the street, facing the terminal stations.

The accompanying cut shows the present railway terminals, and the union station formerly proposed by Mr. Sattley. We are indebted to Mr. Delano for a description of his project, and from this we make the following extracts:

The idea contemplates bringing in the passenger tracks say 20 ft. above the present surface and slightly above the viaduct level, utilizing the entire space beneath them from 12th to 14th Sts., and from State St. to the river, and (if needed) west of the river, for handling on the present ground level, baggage, express, mail, and "less than-carload" (L. C. L.) freight. The proposed stations, five of which would be located east of the river (and, when needed, one in addition west of it), would be separated from each other by the streets running north and south, some of which would be elevated. State St. and Wabash Ave. would run through as now, while Clark St. and Fifth Ave. would be raised to the level of the viaduct at 12th St., and would come down to the present grade again in the neighborhood of 16th St. The space under these streets would be utilized in some cases for railway tracks, in others for teams to reach the freight houses, and at the extreme south end, under the diminished head-room, as a convenient means of connecting these freight houses by passages for the trucking of freight. Subterranean galleries running east and west at convenient intervals between 12th and 16th Sts., and reached by elevators, would also connect the warehouses for the handling of baggage, express, mails, and L. C. L. freight, so that not only would the entire story on the boulevard level be used for passenger business, but the present ground level would be assigned for the handling of baggage, express, mail and freight. In this freight warehouse, facilities would be given for handling less-than-carload interchange business in a way that has been many times suggested, but never satisfactorily worked out. This less-than-carload interchange is now accomplished either by loading cars with miscellaneous shipments which have to be switched and rehandled, involving expense and delay in transit; or by teaming, which is more rapid but more expensive. A still further advantage would be that on the western edge of this immense freight warehouse the river frontage would give facilities for delivering to the railways all freight handled by lighters or steamers, so that all the merchants in the city having water frontage, could receive or make deliveries of their freight to or from any railway.

As an engineering proposition this plan presents no serious difficulties, and in fact, makes possible the elimination of some which now exist, because if the arrangement were made with the common consent of all the roads concerned (and it could not well be made otherwise), a re-grouping of the railways would then be feasible which would almost entirely unravel the bad snarls of crossings at Clark and 16th Sts., and at Archer Ave. and 21st St.

The real difficulty in the situation is, obviously, that of bringing together the more or less discordant interests. It is recognized that some companies, seeing their advantage under present conditions over their neighbors, may be unwilling to give up that advantage, even though the new arrangement offers some attractive features. But, perhaps, when the matter is studied carefully, proper means of reconciling these differences will be found.

It certainly is not the intention of the writer to belittle such difficulties, but simply to direct attention to what appears to be a very remarkable opportunity of straightening out a rather bad situation. Chicago, already the greatest city in the middle west, has here a chance of making for itself an ideal railway entrance. It is recognized that no one union station can accommodate the volume of traffic; it is recognized further, that there is such a thing as making a union passenger station too large. But the proposed plan of placing five or six units in convenient relation to each other, and in practical juxtaposition, units which together will serve not only the passenger business, but to a very important extent the freight business of the city, is surely a move in the direction. The plan, too, is susceptible of considerable expansion, because in the location suggested there is no doubt that between State St. and the river as straightened, more than double the present facilities could be provided, with all the space between the river and Canal St. for future expansion.

An improvement in the present situation is very much needed. The extent to which people are actually driven away from Chicago by the aversion they feel for the city, growing largely out of what they see of it as they enter or leave it, means a serious loss. Some one has well said that the gateway of a large city is its railway terminal, and from this gate the great majority gain their impressions. What has already been done in European capitals, and in this country in some of our larger cities hardly needs to be referred to. By co-operation of the railway companies, the municipality, and public-spirited citizens, the railway terminals in Boston, which for a long time were anything but a credit to that city, have been brought up to a high and creditable standard. Immense sums are at the present time being spent for this purpose in New York City and in Washington, and a number of other large cities have large and comprehensive plans in view. Chicago, the leader of them all in importance as a railway terminus, cannot afford to remain behind.

A difficulty in the problem, and one not to be overlooked, is that to carry out the plan in its entirety necessitates a readjustment of ownership in much of the real estate concerned. In all probability the best way would be to pool all property involved within the limits indicated, placing it in the hands of a single large corporation, which would issue securities to the present owners, and be in a position to raise sufficient money to carry out the plan. No very definite estimate has been attempted as to cost of carrying out this scheme; the expense will, viously, vary with the details of the plan as adopted. it is thought that, exclusive of the land, $75,000 would cover the entire cost.

THE ST. MARY'S PARK TUNNEL, N. Y. C. & H. R. R.

As a part of the depression and rectificat work on the Port Morris branch of the Har Division of the New York Central & Hud River Railroad, a short tunnel is being dri under St. Mary's Park. The park is near 14 St. and St. Ann's Ave., in the Borough of Bronx, New York City.

The two most interesting features of this t nel work are the location and loading of holes, and the loading of muck with a ste shovel operated by compressed air. Steam sho have been used before in tunnel work, but ne so far as we know, within the limits of Gre New York. The gneiss and mica-schist of N York break out in much larger chunks than t shales and sandstones of Pennsylvania, whe steam shovels have been used in tunneling, and for this reason the spacing of the drill holes and the charging of the holes on the St. Mary's Park

FIG. 1. STEAM SHOVEL AT WORK IN ST. MARY'S PARK TUNNEL, N. Y. C. & H. R. R. R.

tunnel work will be of particular interest to contractors and engineers as furnishing a precedent for similar work in tough rock.

The top heading, Fig. 3, was first driven from portal to portal, its dimensions being 8 × 12 ft., and the position of the drill holes being as shown. Both dynamite and joveite were used in the heading blasting; the dynamite being 60%, and the joveite of an equivalent grade. There was no material difference in the work done by the two kinds of explosives, pound for pound, and the average amount used was 6 lbs. per cu. yd. of rock. The heading averaged 4 cu. yds. per lin. ft.

The bench is being taken out in two lifts, as shown in Figs. 4 and 5, the upper lift or bench being kept just in advance of the lower bench. Two rows of holes are drilled in each bench, charged and fired in the order shown, the "a" holes being set off in the first blast, then the "b" holes, then the "c" holes. The resulting breaking up of the rock is excellent; the writer has never seen a better example of heavy blasting in a tunnel. The huge muck heap is attacked by a steam shovel, Marion Model 20, Fig. 1, having a yard dipper. Before blasting, the shovel is hauled back about 100 ft. by a line from the hoisting engine which handles the muck cars. These cars are each of 5-cu. yd. capacity, and average about 2¾ cu. yds. of solid rock per load. They are

hauled out in trains of two by a hoisting engine, located at the approach cut, and up an inclined track supported on blocking and trestle, having a sufficient rise to carry the empty cars back by gravity. As soon as the loaded train passes out of the tunnel, the empty train runs in. The muck is loaded in skips by a derrick located on the bank above the approach cut, and dumped either into cars or into a dump heap. This dump heap is used as a stock pile for the crushing and con-

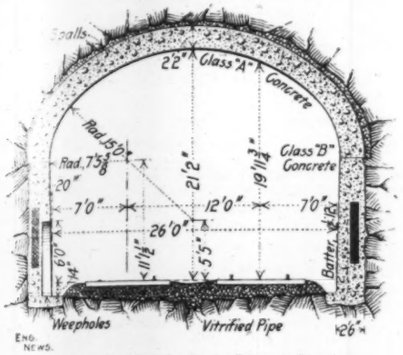


Fig. 2. St. Mary's Park Tunnel Section.

crete-mixing plant, which will be described in a subsequent issue. The shovel is now working about 350 ft. from the south portal of the tunnel, and is giving perfect satisfaction. The crew operating it consists of the two shovel men, four pit men and a pit boss.

The contractors for this work are The United Engineering & Contracting Co., 13-21 Park Row, New York City, of which company Mr. D. L. Hough, M. Am. Soc. C. E., is president. The superintendent of the tunnel and approach work is Mr. H. H. Marden, Jr., M. Am. Soc. C. E.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF WISCONSIN.—The Carnegie Institution of Washington has recently made a grant of $2,500 to Professor C. F. Burgess of the Department of Applied Electro-Chemistry of the College of Engineering, to aid him in carrying out investigations upon the properties of pure iron and its alloys. During the past three years Professor Burgess has developed a method of producing iron electrolytically of a very high degree of purity, in a manner similar to that employed in the refining of copper. Previous to this work pure iron had been obtained only in very

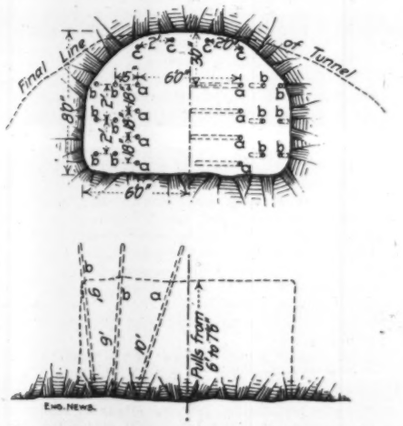


Fig. 3. Front View and Plan of Holes in the Heading.

small quantities and at excessive cost, but Professor Burgess is now able to produce comparatively large quantities at a small cost, using for this purpose a cheap grade of steel. Careful analysis of this product fails to show the presence of any foreign element, with the exception of hydrogen, which can readily be driven off by heat. There is already a considerable demand for this iron for scientific purposes, and about half a ton has already been made.

WORCESTER POLYTECHNIC INSTITUTE.—The thirty-fifth annual catalogue shows that the force of instruction consists of a faculty of 16 professors and assistant professors, and 21 instructors and assistants, besides many assistants in the Washburn Shops. The student enrolment is the largest yet recorded, being 324. The list of graduates shows that 992 are now living.

RENSSELAER POLYTECHNIC INSTITUTE.—The trustees of the Rensselaer Polytechnic Institute have decided to buy at a cost of $125,000 a plot of land adjacent to the land upon which the Electrical Laboratory is situated. This land is at the head of the main cross street of the city, and the building for which Andrew Carnegie donated $125,000, will be situated upon it. Mr. J. J. Albright, of Buffalo, of the class of 1868, has subscribed $50,000 towards the erection of a new Chemical Laboratory. The existing Chemical Laboratory is finely equipped but on account of the recent increase in the number of students at the Institute, it is found to be too small. The new Chemical Laboratory will also be placed upon the property to be bought. The extension to the Electrical Laboratory is nearly completed. Part of the addition is now being used for class work. In consequence of the gift of $100,000 received for the Endowment Fund of the Institute the salaries of the heads of the departments of Descriptive Geometry, Chemistry, Pure Mathematics, Electricity and Physics have recently been increased. The number of students is the greatest in the history of the school.

ESTIMATES FOR A MUNICIPAL LIGHTING PLANT for New York City have been submitted to Mayor McClellan by an expert commission, made up of Messrs. Cary T. Hutchinson, Geo. F. Sever and Nelson P. Lewis. This commission estimates that the total cost of a system capable of covering the Boroughs of Manhattan and the Bronx with 6,000 arc lamps and 250,000 16-c. p. incandescent lamps will be about $4,100,000, exclusive of the cost of the real estate.

The report places the total cost of a power station, with a capacity of 10,000 kilowatts, including coal storage, coal handling apparatus, building, complete boiler plant equipment, engines, generators, switchboards and interest during construction, but excluding real estate, at $1,250,000. The total cost of high pressure cables, sub-station buildings, transformers, switchboards, arc lighting circuits, centres of distribution for incandescent lighting, lamp-posts, lamps, meters and all appliances necessary to make a complete operative plant, up to and including the lamps, including the cost of real estate but excluding the cost of the main duct system, all for the capacity of 6,000 watt arc lamps in Manhattan and The Bronx and for 250,000 16-c. p. incandescent lamp equivalents, will be $2,850,000.

The committee estimated that the total annual cost of operating a 7.5 ampere, inclosed, alternating current arc lamp for 4,000 hours a year, including all costs, would be $75.40 a lamp. The total cost for the supply to the incandescent lamps would be $5.15. The total cost of operating this plant for 6,000 arc lamps and 250,000 16-c. p. equivalents, including all operating expenses, depreciation of 7.5% and interest at 3.5% would be $906,000.

The committee has not included in its estimates the cost of construction of ducts for cables nor any rental charges for duct space.

The general plan of the committee contemplates the construction of one power station for the supply of Manhattan and The Bronx, a second for Brooklyn and Queens, and a third for Richmond. The stations for Manhattan and The Bronx and for Brooklyn and Queens would be interconnected, so that each could supply either borough.

The station for Manhattan and The Bronx should be placed on the East River in Manhattan, but as this cannot be determined at once, the committee assumes that this plant will be erected on the east side of Blackwell's Island.

For Brooklyn and Queens an excellent water-front site is available sufficiently near to the site of the proposed Manhattan plant to permit easy cross connection by way of Blackwell's Island Bridge.

THE PENNSYLVANIA RAILROAD SYSTEM, including all railway lines owned and operated by and associated in interest with the Pennsylvania R. R. Co., had a total extent on Dec. 31, 1904, of 10,588.25 miles of main line and 21,188.51 miles of track. These figures are taken from the annual publication compiled by the Chief Engineer of Maintenance of Way. The Long Island R. R. system is included in these totals; but not the Baltimore & Ohio, in which the Pennsylvania R. R. Co. holds a large but not a controlling interest.

AN EXPLOSION OF FIVE TONS OF DYNAMITE at the No. 3 shaft of the North Kearsarge branch of the Osceola Consolidated Mine, Michigan, on Feb. 8, killed ten men, severely injured others, and jeopardized the lives of many more. The property loss is reported to be considerable. The dynamite was kept in a magazine underground. It is surmised that the thawing of the dynamite caused the accident.

A WATER-WORKS RESERVOIR AT FORT WAYNE, Ind., failed on Feb. 6. The reservoir was of earth and had a capacity of about 3,000,000 gallons. A cave-in occurred on the inner slope and a crack appeared 150 ft. long, and

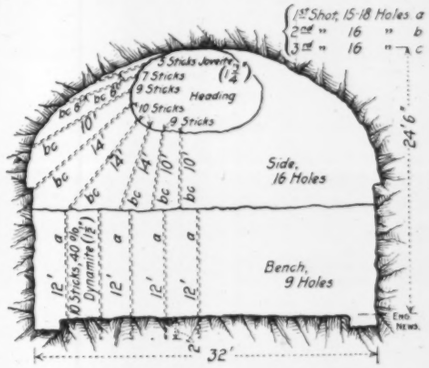


Fig. 4. Front View of Holes in the Benches.

in some places 1 ft. wide, along the top of the embankment.

THE GREENE-GAYNOR CASE was decided by the Privy Council of Great Britain on Feb. 8 in favor of the United States. The decision of Justice Caron, of Quebec, of Aug. 13, 1902, was reversed and the costs of the appeal were assessed on Greene and Gaynor. The case is now open for a resumption of extradition proceedings in Canada to bring these notorious conspirators back to the United States and place them on trial. It is now six years since Greene and Gaynor were indicted for conspiring with former Capt. Oberlin M. Carter to defraud the United States, and Carter's investigation and court martial took place prior to that time. One would search far to find a case where greater delay has occurred between the commission of a crime and the bringing of the offender to trial.

MORTAR COMPOSED OF LIME AND BURNT CLAY was used extensively in constructing the Asyût Barrage completed in 1902, across the Nile, and described in detail in a paper by Mr. George Henry Stephens, M. Inst. C. E., to the Institution of Civil Engineers on March 15, 1904. After being burnt the clay was ground and passed through 400 mesh sieve. The best results were had with a clay burnt to a light terra cotta color as compared with clay burned brick-red and clay burned dark red to purple. The ground clay was mixed with slaked lime and sand was added to form a mortar. The following are the results of long time tensile tests made with various mix-

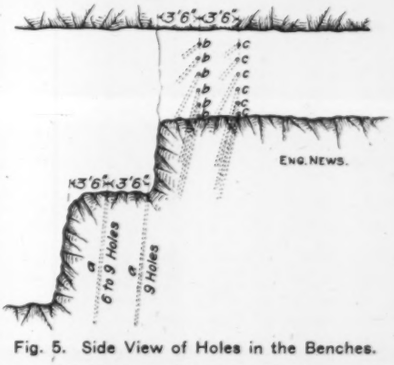


Fig. 5. Side View of Holes in the Benches.

tures molded into standard briquettes kept in water after 12 hours in air:

Mixture by volume.	Age 1 year.	Lbs. per sq. in.	Age 2 years.	Lbs. per sq. in.
3 clay, 2 lime	Maximum	400	Maximum	410
	Av. of 52 samples	272	Av. of 56 samples	320
1 clay, 1 lime	Maximum	305	Maximum	350
	Av. of 38 samples	239	Av. of 25 samples	291
¾ clay, 1 lime, ¾ sand	Maximum	320	Maximum	376
	Av. of 37 samples	259	Av. of 55 samples	280

ENERGY CONSUMPTION IN POLYPHASE ELECTRIC traction on the Valtellina Ry. of the South Italian Railway Co. during the past operating-year was as follows:

Total energy generated, measured by the switchboard watt-meters, 3,420,560 KW.-hrs. Total traffic, 52,493,000 ton-miles (in tons of 2,000 lbs.). The energy generated per ton-mile was, therefore, 65 watt-hours per ton-mile. This figure includes: losses in machinery and conductors, current for lighting cars and stations, current for switching service, current for driving the machinery in repair shops, etc. On a test run with a 125-ton train the energy consumption required only for running and lighting the train was found at 51 watt-hours per ton-mile. This includes losses in generation and transmission. The figure includes 2.6 watt-hours per ton-mile, average, energy returned to the line in downhill coasting and in braking. Had this not been returned the energy consumption would have been about 54 watt-hours per ton-mile. The amount of energy consumed in switching, in station lighting, shop-driving, etc., compared with the energy used for moving and lighting trains, will naturally vary greatly among different railways. The last-given figure, 51-54 watt-hours, should therefore be taken in preference to the gross figure 65 watt-hours, in applying the results on this line to other railways. The trains operating on the Valtellina line vary greatly in speed and weight; the heavy freight trains reach nearly 400 tons weight. The density of traffic during the year 1903-04 was 581,545 ton-miles per mile of line.

PERSONAL.

Mr. Edward P. Byrne has been appointed City Engineer of Medford, Mass.

Mr. James F. Bigelow has been reappointed City Engineer of Marlboro, Mass.

Mr. George A. Carpenter has been reappointed City Engineer of Pawtucket, R. I.

Mr. Thomas C. Camp has been elected Superintendent of Water-Works of Newport, Vt.

Mr. George A. Carter has been reappointed Superintendent of the Water Department of Chicopee, Mass.

Mr. Daniel F. Sullivan has been elected Superintendent of Water-Works of Dallas, Tex., to succeed the late Thomas H. McGraw.

Mr. Alfred Lovell has been appointed Superintendent of Motive Power of the Atchison, Topeka & Santa Fe Ry., with headquarters in Chicago, Ill.

Mr. F. H. Latimer has been appointed Chief Engineer for the Southern Ohawagan Development Co., and will make his headquarters at Penticton, B. C.

Mr. F. W. Dalrymple, formerly City Engineer of Jamestown, N. Y., has been appointed City Engineer of Bayonne, N. J., succeeding Mr. Emmett Smith, who resigned that position a short time ago.

Fred. C. Davis, for the past 7½ years in the employ of the Metropolitan Water Board of Clinton, Mass., has resigned his position to accept a position with the U. S. Reclamation Service in the West.

Mr. J. H. Hargreaves has been appointed Public Works Commissioner and City Engineer of Edmonton, Canada. Mr. Hargreaves was connected formerly with the city engineer's department of Winnipeg.

Mr. W. D. Lovell, M. Am. Soc. C. E., sailed from New York Feb 15 to take up abroad some investigations in his special line of work, namely, water supply. His investigations will cover a period of several months.

Mr. Claude L. Gargot, E. M., has resigned as Engineer of the Kountze Bros. West Virginia and Kentucky Coal interests and has opened an office in Williamson, W. Va., for the practice of Civil and Mining Engineering.

Mr. George H. Stevenson has resigned his position as Superintendent of the Bessemer Water-Works Co., of Bessemer, Ala., and will in the future devote his time to the office of land agent of the Bessemer Coal, Iron & Land Co.

Mr. F. H. Todd, M. Am. Soc. C. E., has resigned as Engineer for the Sabine Produce & Irrigation Cb., of Orange, Tex., and henceforth will engage in private practice, making a specialty of irrigation and water power development. Mr. Todd will be located at El Paso, Tex.

Mr. John B. McDonald, the contractor who built the New York Subway, has had compiled a newspaper history of the opening of the road. The history, which was compiled by a press clipping bureau, is made up of everything printed on the subject in the larger newspapers of the country.

Mr. Charles Evan Fowler, M. Am. Soc. C. E., delivered a lecture before the engineering students of the University of Washington, at Seattle, Feb. 3, on "The Relation Between the Engineer and the Contractor." This is the first of a series of six lectures on the Law of Contracts and Specifications.

Mr. W. G. Cooper, formerly Secretary of the R. H. Hood Co., and Mr. J. M. Evans, C. E., who was Superintendent for the same company, have formed a copartnership to carry on a general contracting business Their present address is 1043 Bergen St., Brooklyn, N. Y., and they will shortly open offices in New York City.

Mr. H. S. Reynolds, who, for the last four years, has managed the Stone & Webster interests in Columbus, Ga., consisting of all the street railway, electric light and gas properties in that city, has resigned to accept a position in the Operating Department of J. G. White & Co., Engineers and Contractors, 43 Exchange Place, New York, where he will reside in the future. Before going to Columbus, Ga., Mr. Reynolds was connected with the Brockton, Mass., Street Railway Co., in charge of construction. Mr. Reynolds was graduated from Massachusetts Institute of Technology in the class of 1894, and since graduation has devoted his entire time to the construction and operation of street railway, electric light and gas plants.

Obituary.

William K. Ackerman, President of the Illinois Central R. R. from 1877 to 1884, died of heart disease Feb. 7, at his home in Chicago.

Roe H. Smith, a contractor, died of heart failure Feb. 11, at his home in Flushing, N. Y. He is said to have laid all the macadamized roads in that town. He was 70 years old.

Mr. John A. McDonald, M. Am. Soc. C. E., Chief Engineer of the Russian-American Steel Company's works at Mariopol, Siberia, was shot and killed by a Russian Colonel of Engineers about two months ago, because he refused to permit certain material to be taken away from the works without being receipted for. Mr. McDonald was formerly in the employ of the Carnegie Steel Co. at Pittsburg. Mr. Chas. Francis, M. Am. Soc. C. E., also in the employ of the same company, was imprisoned but was later released through the intervention of the American Ambassador, and has since returned to the United States.

James C. Spencer, formerly Vice-President of the Milwaukee & Northern R. R., died Feb. 2 at Miami, Fla., aged 76 years. Mr. Spencer began his railway work in 1848 when he became rodman on the New York & Erie R. R. He was Assistant Engineer for the Hudson River R. R., from 1849 to 1851, and Resident Engineer of the same road from the latter date to May, 1852. He then became Resident Engineer of the Chicago & Mississippi Ry., holding this position until 1856. In January, 1861, he was appointed General Manager of the Milwaukee & Prairie du Chien, now a part of the Chicago, Milwaukee & St. Paul, and dating from October, 1875, was for many years Consulting Engineer of the Pittsburg, Ft. Wayne & Chicago. He was appointed Receiver of the Milwaukee & Northern in 1879, and in June, 1880, was elected Vice-President of that company. He was also for a time Vice-President of the Wisconsin & Michigan.

Sylvester Scovel, an engineer and promoter of Cuban enterprises died Feb. 11, in Havana, Cuba, after a recent operation for appendicitis. He was Consulting Engineer for the U. S. Military Government in the Cuban Customs Service from 1899 to 1902. Mr. Scovel had led an adventurous life, having served as war correspondent in the Cuban-Spanish War, the Spanish-American War and the Turco-Greek War. In the Cuban-Spanish War, he lived with the insurgents for eleven months at different visits, running the Spanish military and police lines 20 times before being captured and imprisoned by the Spaniards at Sancti Spiritus, Cuba. Pressure was brought to bear by the U. S. Government and Mr. Scovel was released. After the Turco-Greek War Mr. Scovel was sent to Spain and then to the Klondike, thence to Havana, arriving there just before the blowing up the Maine. He was with the United States army and navy till the American occupation of Santiago and the Spaniard evacuation of Havana on Jan. 1, 1899. Previous to entering upon his career as a war correspondent Mr. Scovel was timekeeper in blast furnace construction in Tennessee, Assistant Superintendent of Water-Works in Kentucky, a mechanical draftsman in Pittsburg, and a promoter in Chicago and Cleveland. He was 36 years old.

ENGINEERING SOCIETIES.

COMING MEETINGS.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 28, 1905. Annual meeting at Toronto, Ont. Secy., Killaly Gamble, Temple Bldg., Toronto.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 21, 22, 23. Annual meeting at Chicago. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 S. 10th St., Philadelphia, Pa.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American committee, W. F. Allen, 24 Park Place, New York.

MASTER CAR BUILDERS' ASSOCIATION.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.—At the February meeting, held at the Council Chamber, Seattle, Wash., a paper on "Concrete-Steel Design a Construction," was read by Mr. C. F. Graff, of the Gr Northern Ry. Secy., Milnor Roberts.

ENGINEERS' CLUB OF COLUMBUS.—The annual ba quet of the club was held at the Hotel Hartman, Colu bus, O., on the evening of Feb. 4, under the presidency Prof. W. T. Magruder. A number of visitors from oth cities were present, among them representatives of th engineers' clubs of Cincinnati and Cleveland. Secy., H M. Gates.

MONTANA SOCIETY OF ENGINEERS.—The followin officers were elected at the annual meeting, held at Butt Mont., on Jan. 14: President, Mr. E. W. King, of Boz man; Vice-Presidents, Messrs. B. H. Dunshee, of Butt and E. C. Kinney, of Bozeman; Secretary, Mr. C. H Moore, of Butte; Delegate to the Association of Engine ing Societies, Mr. S. Barker of Butte.

CIVIL ENGINEERS' SOCIETY OF ST. PAUL.—At th society's annual meting, held at the Merchants' Hotel, S Paul, Minn., on the evening of Jan. 9, the following offi cers were elected for the coming year: President, Mr. A S. Starkey; Vice-President, Mr. Oscar Claussen; Secretary Mr. C. L. Annan; Treasurer, Mr. J. P. Wolff; Librarian Mr. C. R. Winslow; Delegate to the Association of Engineering Societies, Mr. G. R. Wilson.

IRON AND STEEL INSTITUTE.—The annual meeting will be held on May 11 and 12, 1905, at the house of the Institution of Civil Engineers, London, England. In the evening of the second day the annual dinner will take place at the Hotel Cecil. The awards of Carnegie Research scholarships for the next year will be made at this meeting. The autumn meeting of the Institute is to be held at Sheffield on Sept. 25 to 29, 1905. Secy., B. H. Brough, 28 Victoria St., London.

BROOKLYN ENGINEERS' CLUB.—At the club's meeting of Feb. 9, 1905, an interesting paper was read by Mr. R. C. Strachan, on the subject "Calculation of Stresses in the Blackwell's Island Bridge." The paper is reprinted in full on another page of this issue. Several communications in discussion of the paper were read. Mr. Elwin Duryea referred to several notable American cantilevers not mentioned in the list given in the paper, the Wabash Ry. bridges at Pittsburg and Mingo Junction, 812 and 700 ft. in span respectively, and the Thebes bridge over the Mississippi, 671 ft. longest span. Commenting on the type of frame adopted, Mr. Duryea held that the omission of the suspended span calls for justification; the increase in complexity of truss system must realize countervailing advantages, of rigidity, economy, or the like, to justify it. Referring to the assumption as to "probable" maximum live load, he mentioned that a more accurate method of estimating probable maximum load had been used by Mr. Joseph Mayer in designing a railway bridge across the North River. Mr. H. W. Hodge, after commending the procedure used for the calculation, said that he sees no reason for adopting a semi-continuous form of bridge; any slight possible gain in appearance, which in fact is not realized, would not be adequate reason for using this type. A pure cantilever bridge with a suspended span of say ⅜ the span between piers would be fully as rigid and would not suffer from settlement of piers, which is always possible. Moreover, with the semi-continuous bridge, a difference in expansion of top and bottom chord may set up serious temperature stresses, and this is not unlikely with bottom chords covered over by the roadway. Mr. Joseph Mayer also expressed preference for the ordinary type of cantilever. Mr. L. S. Moisseiff came to the defence of the type of structure adopted. The type is not new, several similar but much smaller structures having been built in Austria. The design reduces the deflections under live load, Mr. Moisseiff claimed, and hence also the vibration. The enormous weight of the structure, operates to make the usual rule for economical length of suspended span inapplicable. Any suspended span would be so heavy, and would require such excess for erection stresses, that its economy would disappear. Mr. Moisseiff also referred to the detailing of the structure as extremely difficult work, requiring all refinements of secondary stress, etc., to be considered. Moreover, the individual members are of such size that it is doubtful whether the assumed proportionality of strength to area holds accurately.

Mr. O. F. Nichols, Chief Engineer of the Department of Bridges, after characterizing the Blackwell's Island Bridge as a contribution of architecture to engineering and hence an unfortunate compromise, referred briefly to earlier designs for a bridge at this point, the last of which, preceding the present design, was a cantilever of ordinary type. He personally believes that a two-span suspension bridge is the most suitable for this location. Speaking, then, in some detail of the width and traffic capacity of the structure, Mr. Nichols expressed the opinion that the roadway as designed is far too narrow to accommodate the street traffic which will come upon it. He expects that the roadway will be overcrowded as soon as the bridge is opened. The provision of two lines of elevated railway as originally made, would also have proved a serious error, but the four tracks now provided will suffice for some years. One or two details of the structural design were also discussed by the speaker. Secy., Jos. Strachan

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, February 16, 1905.

CONTENTS.

EDITORIAL:
Reinforced Concrete Now an Accepted Term.—Books Containing Information on Shaft-Sinking..... 179
CORRESPONDENCE:
On the Sign of Bending Moment: Sanford A. Moss. —Smoke Prevention and Fuel Economy: A. Bement.—Names for Steel Foundry Products: E. R. T. Berggren 179
REVIEWS:
Gas Engines and Producers. Reviewed by Prof. Storm Bull 180
The Science Year-Book..... 181
The Naval Constructor. Reviewed by Prof. Amasa Trowbridge 181
The Downfall and Uplift of a Chicago Architect.... 181
The Mineral Industry During 1903..... 181
Structural Designers' Handbook. Reviewed by R. P. Miller 182
Two Electrical Laboratory Manuals..... 182
A French Work on Canal Construction..... 183
An Introduction to Projective Geometry. Reviewed by Prof. Virgil Snyder..... 183
Der Wasserbau 183
The Future of Road-Making in America..... 183
Suction Gas. Reviewed by Alfred E. Forstall..... 184
Stresses in Simple Trusses..... 184
The Constitution of Hydraulic Cement..... 184
Geological Survey Reports..... 184
Sketch Portfolio of Railroad Stations..... 184
Pioneer Irrigation and Light Railways..... 185
The Epidemic of Typhoid Fever at Ithaca, N. Y.... 185
The Relation of Preventable Diseases to Taxation.. 185
Petrol Motors and Motor Cars. Reviewed by Prof. Storm Bull 186
Elementary Course in Mechanical Drawing..... 186
Literary Magazines..... 188
Publications Received 188

The indiscriminate use of the terms concrete-steel, steel-concrete, reinforced concrete, ferro-concrete, etc., for concrete reinforced by steel is deplored by a valued correspondent in a letter addressed to the editor of this journal. To clear up the confusion the writer of the letter suggests that engineers should endeavor to settle upon some one term and use it to the exclusion of all others. The term chosen by our correspondent as best meeting the case is steel concrete, the argument for the choice being that the material under consideration is a special kind of concrete in which steel is just as truly an ingredient as is the cement, sand or stone, and as we have natural cement concrete and Portland cement concrete, so should we have steel concrete. We shall not attempt to weigh the merits of the term steel concrete as compared with the other terms named, and we do not as a matter of fact believe that abstract considerations of fitness will have much to do with the matter whichever the term may be that is finally chosen. Meanwhile it may be remarked that two prominent engineering organizations, the American Society of Civil Engineers and the American Railway Engineering and Maintenance of Way Association, have expressed themselves in favor of the term reinforced concrete, that the engineering papers generally use this term, and that practicing engineers are about equally divided between it and the term concrete-steel. The facts being as stated it would seem advisable to follow the lead thus established for the term reinforced concrete, rather than to set up a less favored term, however reasonable and logical its derivation may be.

Books Containing Information on Shaft-Sinking.

A correspondent who desires to secure information on shaft-sinking has sent us the following letter, to which we append an answer:

We have been investigating the subject of shaft-sinking with particular reference to coal mine shafts, and have examined the following books:

"The Colliery Manager's Hand Book," by Caleb Pamely; "Coal Mining," by T. H. Cockin; "Coal Mining," by James Tonge, Jr.; "A Conversation on Mining," by Wm. Hopton; "A Manual of Mining," by M. C. Ihlseng, and "Coal and Metal Miners' Pocket Book," by the Technical Supply Company.

The above named books may cover the subject as thoroughly as any others published, but they do not give us as much information as we desire to get. We shall appreciate it very much if you can supplement this list from your own knowledge and experience.

Of the American books that treat of shaft-sinking, our correspondent has mentioned two: Ihlseng's "Manual of Mining," and the "Coal and Metal Miners' Pocket Book," the former having 40 pages on shaft-sinking in the latest (4th) edition, and the latter 6 pages. There are three other American books in which shaft-sinking is discussed. The oldest of these is Drinker's "Tunneling," which has a 97-page chapter on sinking, a large part of which is taken up with illustrations showing methods of timbering shafts. This chapter is the longest on the subject ever published in any book; and, in spite of the fact that it has not been revised since 1878, much of the matter (excepting the cost data) is applicable to-day. The price of the book ($25) stands in the way of its common use.

Gillette's "Rock Excavation: Methods and Cost," contains a short chapter giving brief descriptions of methods of attack and the actual costs of shaft-sinking in rock in several different American mines. The itemized cost data on shaft-sinking and timbering are up to date and more complete than are to be found in any other book. References are also given to a number of recent articles on shaft-sinking. Data given in other parts of the book, relative to drilling and blasting, also apply to shaft-sinking.

Taking up books by English authors, we find that Pamely's book (mentioned by our correspondent) contains 22 pages on shaft-sinking. We have examined nine other British books; the names of which and the number of pages in each devoted to shaft-sinking will now be given:

"Deep Level Mines of the Rand," by G. A. Denny, 4 pages and 3 folding plates showing timbering.

"The Miner's Handbook," by John Milne, 8 pages.

"A Text Book of Ore and Stone Mining," by C. LeNeve Foster, 1 page on sinking in rock, and 14 pages on sinking in quicksand, and 10 pages on timbering and lining.

"Mining," by Arnold Lupton, 60 pages on sinking, including descriptions of drills, cages, etc.

"Economic Mining," by C. G. W. Lock, 8 pages.

"Gold Mining and Milling in Western Australia," by A. G. Charleton, 10 pages.

"An Elementary Text-Book of Coal Mining," by Robert Peel, 20 pages.

"Coal Mining," by H. W. Hughes, 36 pages.

"Practical Coal Mining," by G. L. Kerr, 36 pages.

A cursory examination of all these chapters on shaft-sinking in these British works shows that for the most part the authors have copied one another or have copied from the same original papers on shaft-sinking. Moreover, the chapters are in most cases so short that the description of shaft-sinking is sketchy. Even the chapters that are relatively long are practically short, because so many kinds of shaft-sinking are touched upon. Special processes for sinking in quicksand often receive more space than is given to sinking in ordinary kinds of rock. The number of pages is not necessarily a criterion of the value of a chapter, for one hint from a practical man, although it occupies but few lines, may be worth the price of the book a hundred fold.

Unfortunately, few of these English books appear to have been written by engineers experienced in shaft-sinking. Nor have the authors availed themselves of the best that exists in print in technical journals.

CORRESPONDENCE.

On the Sign of Bending Moment.

In the "common theory of the flexure of beams" the "bending moment" about a given point on the neutral axis is defined as the sum of the moments about that point of all external forces between the point and either end of the beam. The bending moment M as thus defined enters into the well-known fundamental equations of the theory of flexure,

$$S = \frac{M c}{I}, \text{ and } \frac{d^2y}{dx^2} = \frac{M}{E I}.$$

Considerable confusion exists concerning the sign of a bending moment and no consistent convention is used by the various writers on the subject of flexure. In some cases a writer uses different conventions in different places. In other cases the convention used is not stated. In many instances the convention used is such that stresses and deflections come out negative at times, regardless of meaning. In one case a writer uses the sign ± in the above equations, the idea being that such a sign is to be chosen as will make the stresses and deflections positive in each case. For simple cases the confusion does not cause any difficulty, as the character of the stresses and deflections are known by general considerations, and independently of the signs given by the equations above. For complicated or unfamiliar cases, the confusion may often become serious.

It will be the purpose of this note to show that there is no reason for any confusion in this matter, and to develop a very simple and rational convention for the sign of a bending moment. If this convention be used the stresses and deflections will have signs according to a consistent system, and a negative stress or deflection will have meaning.

As is usual, we assume as the axis from which deflections are measured, the line of the neutral axis of the unloaded beam. Values along this axis are denoted by x, and deflections from it by y. We will assume a horizontal beam, although the results are of course perfectly general and apply to any inclination. We will count downward deflections as positive, so that upward deflections will be negative. That is, if the value of a deflection comes out positive, it indicates a position of the neutral axis below the zero line, and if it comes out negative, a position above the zero line.

It is convenient in beam problems to take the positive direction of x sometimes as being toward the right, and sometimes toward the left, so that x may always be positive. As will be seen presently, the direction in which we suppose x positive affects only the sign of dy/dx and has no effect on other signs. Sometimes it will be convenient in a single problem to count the positive direction of x toward the right for some segments of the beam, and toward the left for other segments. No confusion is caused thereby if we note that the meaning of the sign of dy/dx only is reversed, as will be shown presently.

If x is positive toward the right (y being positive downward as stated) then dy/dx is positive when the tangent to the elastic curve slants downward from left to right, as in the case of a cantilever, with support at the left and load at the right. If x is positive toward the left, dy/dx is positive when the tangent to the elastic curve slants downward from right to left.

For either positive direction of x, the value of d^2y/dx^2 is positive for curvature such that a positive tangent to the elastic curve makes a successively increasing angle as we proceed in the positive direction. Reflection will show that for either case this is the necessary and sufficient condition that the elastic curve is *convex upwards*. Hence, in any case, a positive value for d^2y/dx^2 indicates that the elastic curve is convex upwards, as in the case of a cantilever. A negative value indicates contrary curvature, as in the case of a beam supported at both ends.

If the elastic curve be convex upwards, there must be tension on the upper fibers and compression on the lower ones, and hence this state of affairs corresponds to a positive value of d^2y/dx^2. Therefore, when writing for any particular case the value of M for forming the equation,

$$\frac{d^2y}{dx^2} = \frac{M}{E I}$$

we must arrange the signs so that d^2y/dx^2 will be positive when the bending moment is such as to cause tension on the upper fibers, and compression on the lower ones. That is to say, a bending moment with such a direction must accompany a positive value for d^2y/dx^2. Since E and I are essentially positive, this is accomplished by assigning a positive value to the bending moment itself when in such a direction. The rule for the sign of a bending moment, therefore, comes out as follows:

Rule:—A bending moment tending to cause tension on the upper fibers and compression on the lower ones, is to be counted as positive, while one tending to cause tension below and compression above is negative.

The total bending moment in any case is, of course, the algebraic sum of all positive and negative moments due to individual forces. It is to be noted that this rule is equivalent to stating that a positive bending moment tends to cause curvature such as is found in a cantilever, while a negative bending moment tends to cause curvature such as is found in a beam supported at both ends. It is also to be noted that the sign of a bending moment cannot be given by the direction in which it tends to cause rotation, since a positive bending moment tends to cause counter-clockwise rotation if at the left of the point about which moments are taken, or clockwise rotation if at the right.

Some writers fix the sign of a bending moment by the direction of rotation, regardless of the relative position, with the result that their stresses and deflections come out positive and negative without any meaning whatever.

According to our rule, the bending moment due to a

load is always positive, and that due to the reaction of a support is always negative. However, the rule applies not only to moments due to such single forces, but also to "couples." Couples occur when restraining moments are exercised by supports at points where a beam is "fixed," and when a portion of a beam is supposed to be removed and replaced by forces equivalent to the internal forces at the point of section. Usually such a couple is originally unknown and is represented by an undetermined constant m, which is solved for in the course of the investigation. This m is initially to be supposed positive, that is, of such direction as to cause tension above and compression below. If the finally determined value of m comes out negative, then the direction is opposite to that assumed. In the treatment of continuous beams and the development of the three-moment theorem, an undetermined couple m arises, equivalent to internal forces of a point of section, and the rule of signs here developed becomes particularly useful.

If the above rules be followed in forming the bending moment, it is evident by virtue of the relation,

$$S = \frac{Mc}{I}$$

that the stress will have the same sign as the bending moment, since c and I are essentially positive. Hence: A positive value for the extreme fiber stress indicates tension in the upper fibers and compression in the lower ones, and a negative value, the reverse.

Resumé.—In the theory of the flexure of beams, x denotes distances measured along the neutral axis and may be taken as positive in either direction. Even in a single problem, the positive direction may be different for different segments. Difference in the positive direction for x reverses the sign of dy/dx, and has no other effect.

In general, a positive bending moment is one tending to cause tension on the upper fibers and compression on the lower ones, or it is one tending to cause curvature such as found in a cantilever, the convex side being upward. The bending moment due to a downward load is always positive, that due to the upward reaction of a support is always negative.

A positive value of the deflection y indicates downward deflection; a negative value, upward deflection. A positive value for the stress indicates tension in the upper fibers, and compression in the lower ones. A negative stress indicates the reverse.

Yours truly,

Sanford A. Moss.

West Lynn, Mass., January, 1905.

"Smoke Prevention and Fuel Economy."

Sir: Under the title Smoke Prevention, on page 50 of your issue of Jan. 12, appeared a review of a book entitled "Smoke Prevention and Fuel Economy." The review contained some statements which will bear examination.

Referring to furnaces, the article closes with these words: "The real problem is to design a furnace that the ordinary $12 a week fireman will not permit to smoke in practice. This is a far more difficult problem and one that has yet to be solved." Excluding for the present the question of amount of pay that the man may receive, I will say that such furnaces as it is stated have not yet been developed have been in continuous and satisfactory service for some years, and I will express my surprise that the writer of the review is not aware of this fact. These furnaces to which I refer were devised and installed by the Chicago Edison Co. some four or five years ago. They consisted of a tile roof suspended from the lower row of tubes of water tube boilers and extending nearly the entire length of the boilers and having a chain grate stoker below. With these tiles in proper condition and the roof intact there is no smoke made and it is not in the power of the furnace operator to make them smoke if he tries. Following the practice inaugurated by the Edison Co., the Heine Safety Boiler Co. has adopted this tile roof for all of its product; therefore, anyone buying one of these boilers, and equipping it with a chain grate stoker may secure a "smoke proof" apparatus. During a recent visit to the new and elaborate coal mining operation of the Zeigler Coal Co. in Franklin County, Ill., I observed the above combination in service and could not determine from the appearance of the chimney whether or not there was fire under the boilers. At the recent Louisiana Purchase Exposition held at St. Louis the exhibit of the Heine Safety Boiler Co. was equipped with this tile roof and chain grates. These units made no smoke whatever, while all of the others produced smoke, which at times, from some of them, rolled out in great volume. The chain grate is the only stoker which can be employed in an absolutely smokeless apparatus, because it always feeds the fuel with mechanical exactness; the fire does not have to be disturbed for the removal of ashes and the operator cannot disturb the normal feed of the coal.

After an extensive experience I have arrived at the conclusion that we are disposed to expect too much from the firemen, and that it is quite the fashionable method to blame him for things for which the designing engineer is responsible.

The employment of colored glass through which to view the fire is an excellent scheme; it, however, is not new. Blue eye glasses and spectacles have long been employed in connection with operation of open hearth and similar furnaces. Many people use them to inspect the flames and by the employment of different colors and shades of the same color endeavor to discover the condition of combustion. I, however, never realized any advantage in this method and use glasses which enable me to see the fuel bed or charge and judge of its physical condition. A certain shade of brown glass called "smoked glass" is best for the purpose. It is often impossible with the unprotected eye to see the fuel bed, but the smoked glass not only enables the fire to be seen, but protects the eye from the fierce glare. In a number of cases I have had the men supplied with these glasses to advantage.

It is stated that "pure" carbon will not combine with oxygen, but that there must be some hydrogen present for combination to occur. This does not agree with accepted explanation. The gem diamond may be burned if the initial temperature is high enough, yet such diamond is considered to be composed of carbon only, or, in other words "pure" carbon. The difficulty of ignition of anthracite as compared with bituminous coal is better explained by physical than by chemical condition of the fuel.

It is stated that CO is never formed directly. This appears to indicate that the reaction is $C + 2O = CO_2$, which is not in accordance with the sequence of similar reactions. If the process is considered to be other than represented by the three following equations:

$$(1)\ C + O = CO,$$
$$(2)\ CO + O = CO_2,$$
$$(3)\ CO_2 + C = 2CO,$$

it would have been in order to have stated the reason for such opinion.

Very truly yours,

A. Bement.

218 La Salle St., Chicago, Feb. 2, 1905.

Names for Steel Foundry Products.

Sir: In your issue of Jan. 12, 1905, you raised the question of the term "cast steel" as applied to foundry products. As far as I have heard the term used, I have noticed a distinction between the material "cast steel" and the "steel casting" as a product of the foundry, but I do not consider it conventional, as we say "cast iron" and "cast iron brackets."

We may say: Iron castings, steel castings, bronze castings, etc., in reference to foundry products. We may also say: An iron bracket, a steel bracket, a bronze bracket, without regard to method of manufacture, but these terms are somewhat indefinite and would not be used by technical persons, except in reference to objects whose nature is known. However, we may say with more appropriateness, a cast iron bracket, a cast steel bracket, a cast bronze bracket. When we express both make and material a hyphen may be introduced, as follows: a cast-iron bracket, a cast-steel bracket, a cast-bronze bracket.

I think that it is desirable to be systematic in choice of expressions in this matter, and I would, therefore, suggest abolishing the use of the term "cast steel" for denoting crucible steel or the cast ingots made for rolling mill purposes at both Bessemer and open-hearth steel works.

Yours truly,

E. R. T. Berggren.

New York, Jan. 27, 1905.

MEDICAL HANDBOOKS.—Issued by The Mutual Life Insurance Co., New York. Flexible cloth; 5x7 ins. Sent to any address for 3 cts. in postage. No. 1: Care of Invalids. Pp. 42. No. 2: Emergencies. Pp. 31. No. 3: Accidents. Pp. 44; illustrated. No. 4: Poisons—Remedies. Pp. 45.

HEALTH BOOKLETS.—Issued by The Mutual Life Insurance Co., New York. Paper; 3½ × 5½ ins. Nos 1 to 4: The Summer Series—(1) Sunstroke; pp. 14. (2) Drowning; pp. 12; illustrated. (3) Diarrhoea. (4) Malaria; pp. 23; illustrated. No. 5: Colds and Influenza. Pp. 8. No. 6: Freezing. Pp. 14. No. 7: Hemorrhage. Pp. 18; illustrated.

These handbooks and booklets are of a practical character, and their extended use would contribute materially to lessen the sick and death rates. The booklets deserve particular commendation because they put the essential facts on each topic so briefly and pointedly. Handbook No. 1 needs revision as to the gaseous disinfection of rooms, for which sulphur is described and formaldehyde ignored, and as to the section on house drains, in which it is stated that sewer gas is not so much to be feared in itself as because that when bubbles of it break "on the surface" (of what not stated), disease germs will be carried into the room "by the air currents." As Engineering News has so often pointed out, there is no specific sewer gas, and sewer air is one of the least likely means of spreading disease germs.

The Choice, Installation and Management of Gas Engines and Gas Producers.

Reviewed by Prof. Storm Bull,* M. Am. Soc. M. E.

MANUEL PRATIQUE DES MOTEURS A GAZ ET GAZOGENES.—Guide de l'Industriel, de l'Ingénieur et du Constructeur pour le Choix, l'Installation, la Conduite et l'Entretien des Moteurs et Gazogenes. By R. E. Mathot, Ingénieur-Conseil, M. Inst. M. E., M. Soc. Ing. Civils de France. Paris: Ch. Béranger. Cloth; 6½ × 9¾ ins.; pp. 247; tables and 154 figures in the text. 12.50 francs or $3.75.

If a person did not know beforehand that the author of this book has had an unusually large and varied experience with gas engines and gas producers, there cannot be any doubt but that he would be convinced of the fact after reading the book. The title indicates very clearly what the author has intended to accomplish: to give practical advice to both engineers and designers in the choice, installation, running and maintenance of gas engines and gas producers. It ought to be stated at the outset that he has succeeded admirably.

Before a short synopsis of the book is given, however, it seems advisable to correlate it with some books which the writer has recently reviewed for this supplement: "Die Verbrennungsmotoren" (May 14, 1903), by Güldner, and "The Gas Engine" (Dec. 10, 1903), by Hutton. Güldner's book was primarily written for the designers of gas engines. It gives the most elaborate details of all modern gas engines, and as elaborate rules and formulæ for their design. Necessarily, the advantages and disadvantages of the various designs are thoroughly discussed, and, incidentally, difficulties in operation are mentioned; but these difficulties are not touched upon in order to instruct anybody in running the engine or for the purpose of guiding some engineer in selecting a gas engine for a special purpose. The object is, as stated above, to furnish information for the designer and manufacturer of gas engines. For the same purpose the book also describes and illustrates the principal types of gas engines of former days. Since the review of Güldner's book was written the reviewer has become very familiar with it, and he is now more confirmed than ever in his views expressed at that time that nothing in the literature of the gas engine can be compared with it in thoroughness and wealth of information.

Professor Hutton's book is of yet another kind. It covers the theory of the gas engine very thoroughly; it neglects the design altogether except as to some details which are special to the gasolene engine and to the automobile motor. But some of the best chapters of the book treat of the difficulties found in running the engines, and of how to test gas engines, so that evidently Hutton's book stands between the two others. For American practice his book is without doubt the best so far published in the English language; but it is also certain that the two other books would, if translated, fill a want which ought to be satisfied. From what has just been stated, it is evident that Hutton's book cannot guide anybody in the selection of an engine, nor does it help an engineer in the work of installing one, nor does it treat of the comparative cost of installation and of running a steam and gas engine plant, a point on which M. Mathot gives very valuable information. These points have been mentioned in order to fully establish the different character of the three books.

The first chapter in Mathot's book treats of the cost of installing and running gas engines, especially as compared with modern steam engines. Both ordinary city gas and producer gas are considered, and the author arrives at the conclusion that at least for plants of less than 500 HP. the advantage is decidedly in favor of the gas engine. He states his belief that even for larger plants this advantage, which perhaps now is small, will become quite large in the near future. It needs hardly to be stated that these conclusions are without reference to the use of blast furnace or coke oven gas, and also that the absolute costs, as quoted in the book, would not fit conditions in this country, although it is the belief of the reviewer that the relative cost would be very little different in this country.

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

The second chapter treats of the selection of a gas engine as it ought to be affected by the proper design of the more important part of the motor. The author's thorough knowledge of the subject is very apparent here, and his impartiality equally so.

In the third and fourth chapters the problem of installation is discussed in a very clear and comprehensive manner, and the very best advice is given as to foundations, location, meters, and exhaust.

Chapter V. takes up the question of cooling water from all points of view, and Chapter VI. treats of the lubrication of the engine, both as affected by the kind of oil and by the manner of application.

The next three chapters treat of the necessary conditions for the good running of a gas engine, of how to start the engine, and finally, of how to deal with all those minor difficulties and mishaps which, up to the present day at least, have frequently occurred in the running of gas engines. The treatment of these subjects by M. Mathot is remarkably fine.

Gas engines using producer gas are discussed in the tenth chapter, in which attention is called to the special requirements for these motors. In Chapters XI. to XIII. the producer gas and the apparatus for making it is treated in a very thorough manner. The illustrations are very excellent, and the writer believes that in no other book will be found such a complete description of the various successful and modern suction gas producers, a subject which the author is especially competent to discuss.

The gasolene engines are considered in the next chapter, but it is evident that the author is not particularly interested in this class of motors, except as they are used for automobiles, this fact, being of course, due the limited use of gasolene engines in Europe except for automobiles. However, the author describes a continuous indicator invented by him for indicating automobile engines, which seems to be thoroughly reliable.

The last chapter of the book gives instructions for the proper testing of gas engines, and finally the logs of a number of tests conducted by the author, both for engines using city and producer gas. It is perhaps interesting to note that among the latter there is one test of an Otto engine with Otto suction producer for which the consumption of coal per brake horse-power per hour was found to be only 0.86 lbs. The capacity of the plant was only 60 HP., and so-called "lean" coal, not anthracite, was used. The average compression was 176 lbs. per sq. in., and that at the explosion was 397 lbs. The results are certainly very remarkable for so small a unit.

In conclusion, the writer desires to say that this book shows, as is indicated in so many other ways, that the United States can still learn a great deal about gas engines from European engineers.

THE SCIENCE YEAR-BOOK.—With Almanac, Diary, Biographical Directory, Summary of Progress in Science, List of Scientific Societies and Glossary. For 1905 (first year of issue). Edited by Major B. F. S. Baden-Powell, late Scots Guards, President Aeronautical Society; Author of "War in Practice," etc. London: King, Sell & Olding, Ltd., 27 Chancery Lane, W. C. Cloth; 6 × 9 ins.; pp. 168 + 365; illustrated.

The title to this year-book gives a very fair idea of its contents and the purpose of its editor. But in addition to what is there noted the book contains a large number of useful tables, astronomical data and matter generally interesting to the class of readers for whom it is issued. The summaries of scientific progress are written by specialists in the several branches and concisely state conditions to date. One of the novel features of the volume is a calendar and engagement tablet, so arranged that the calendar is exposed for each month through an opening in the front cover. The purpose of the editor, which is well carried out, is to produce a volume really useful to all interested in Science, and to add to and improve upon the work in succeeding issues; and to this end the editor invites criticism and suggestions. It is published under the auspices of the "Illustrated Scientific News," succeeding the "Knowledge Diary and Scientific Handbook" formerly issued in conjunction with "Knowledge," the latter periodical having now been consolidated with the "News."

A Hand-Book for Naval Architects and Engineers.

Reviewed by Amasa Trowbridge,* Ph. B.

THE NAVAL CONSTRUCTOR.—A Vade Mecum of Ship Design for Students, Naval Architects, Shipbuilders and Owners, Marine Superintendents, Engineers and Draughtsman. By George Simpson, M. Inst. N. A. New York: D. Van Nostrand Co. London: Kegan Paul, Trench, Trübner & Co. Leather; 4½ × 6½ ins.; pp. 588; tables and 288 figures in the text. $5 net.

This hand-book is a compilation of rules, formulas and tables pertaining to shipbuilding, with just sufficient descriptive matter to make the application of the rules clear. There is some original matter in the book and a great deal that has not before appeared in book form. Very little of the material that has been given in previous naval architects' pocket-books appears in this one, but, in its place, the author has given very concise and complete methods for the designing of ships. He has devoted the entire book to the ship itself, leaving the question of engines and boilers to be dealt with by others. As it is necessary to know the power required for propulsion, in order to design the ship, rules for finding that have been inserted, together with data for estimating the weight of machinery for any ship, after finding the power required. Merchant ships alone have been considered, the book being consequently as free as possible from the complications involved in warship design.

The author has endeavored to arrange the book in a logical manner, but he has not succeeded in attaining his object as completely as might be desired. He also repeats somewhat. This is an extremely bad thing to do, as it uses up space which should be devoted to additional matter and makes the book more cumbersome to use. There is no need of any repetition in a book of this character, if a good index is supplied. When a subject has to be looked up in more than one place it wastes time and this point should be very carefully looked after in making up any reference book. Also, the index is not as complete as it should be and the table of contents is simply a list of headings for which no pages are given. On account of this lack of page numbers the table of contents is practically useless. Young naval architects are the ones who have the most difficulty in finding what they want in the index to a hand-book and they are the ones to whom this book will be most useful.

The book is divided into seven sections, of which the last two contain the usual mathematical tables and such special tables as are useful in ship work. Another section give Lloyd's rules for equipment and various tonnage rules. Rigging and Ropes are the subjects for another section and the Strength of Materials is fully treated, tables for the weight and strength of various substances being included.

The first section is devoted to rules for the design of a ship. The method for such design is by a system of coefficients, values for which are to be taken from tables in the book. These tables have been computed from successful vessels and cover a very wide range, from a steam launch to the largest steamships. By the use of these coefficients, it is possible to scheme out the principal dimensions to fulfil a given set of requirements before the lines are drawn. This enables the designer to see what advantage can be taken of the Classification Society's rules, so as to build the ship with the lightest possible scantlings, by making only slight changes in the dimensions. A course of procedure is given for working out the lines after the dimensions are decided upon. This is particularly useful to beginners, but, after one has drawn a set of lines, it is probable he would vary the sequence of the different steps somewhat.

A chapter on Freeboard gives a very clear explanation of this intricate subject. While treating of freeboard, the author also explains the shelter-deck steamer, which is the latest development for getting ahead of the tonnage rules.

To aid designers in proportioning propeller struts, Mr. Simpson has deduced a formula for the area of such struts. He then gives rules for the proportions of length to breadth of the cross-section, to make a definite design possible. The same formula can, by the introduction of constants, be applied to the designs of spectacle-frames which are being used more generally than "A" struts for large steamships. No rules are given, however, for designing round tubes for supporting the shafts, such as were used in the Pacific Mail S. S. Co.'s ships "Siberia" and "Korea." As this last method would seem to be nearly an ideal one for supporting the shaft, without interfering with the flow of water to the propeller, rules for designing the tubes would have been very welcome.

The third section of the book is very largely devoted to standardized fittings. By standardizing the fittings for ships, the cost can be somewhat reduced; hence, the more we use standard fittings and details, the better able American shipbuilders will be to compete with the foreign builders. One of the most important fittings is the anchor, of which several improved forms are shown and tables given for their proportions. Among other things a "bill of material" is illustrated which is decidedly useful as an example of a methodical way to order materials and avoid delays and confusion.

Throughout the entire work the author has given empirical formulas for the solution of any problem. In this way he has avoided the use of higher mathematics and made a book that can be used by anyone who is familiar with algebra. This limits the scope of the book somewhat, but, despite that fact, it is complete enough for designing all the usual types of merchant ships. The book is certainly up-to-date and should receive a warm welcome from all who are interested in ship design.

*Adjunct Professor of Mechanical Engineering, Columbia University, New York City; Late Passed Assistant Engineer, U. S. Navy.

The Downfall and Uplift of a Chicago Architect.

THE COMMON LOT.—By Robert Herrick. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 5½ × 8 ins.; pp. 426. $1.50.

Architects and engineers may here find woven into an interesting and impressive story some painfully familiar facts about loss of professional aspirations and business honor in a mad chase after success, as measured by money and social rank. A well-educated and very ambitious young architect, an old man who made a fortune as a bridge builder, and sold out to a bridge trust shortly before his death, an unscrupulous building contractor, and a cool-headed lawyer with great influence in political and financial circles are among the male characters in this book. The architect is brought to his senses by seeing a building of his own design, which, with his consent and the connivance of the Chicago building department, had been scamped by the contractor, go up in flames like tinder and cause the loss of many lives. He makes a clean breast of it at the coroner's inquest, and, on being taken in again by an architect for whom he worked before opening an office for himself, he begins near the bottom and makes a truer success than before because, although sharing "the common lot" of humanity, he is now working towards a higher ideal. As may be expected, there is a woman to help bring the man to his senses and put him in the right way, but the part she plays can best be learned from the book itself.

THE MINERAL INDUSTRY DURING 1903.—Founded by the Late Richard P. Rothwell. Prepared by The Editorial Staff of the Engineering and Mining Journal. The work on this volume has been more particularly under the supervision of Mr. D. H. Newland. Volume XII. New York and London: The Engineering and Mining Journal. Cloth; 6½ × 9½ ins.; pp. 574; tables and figures in the text. $5.

This excellent compendium of the mineral industry in America needs no editorial comment further than to call attention to the special articles that it contains in addition to the mineral statistics. The following are the contributed articles and their respective authors, the figures in parenthesis indicating the number of pages in each case: "The California Asphaltum Industry" (6), by F. H. Minard; "Review of the Cement Industry" (3), by Robert W. Lesley; "Progress in the Metallurgy of Copper" (36), by L. S. Austin; "Uses and Technology of Fluorspar" (3), by F. Julius Fohs; "Production of Gold and Silver in the U. S." (8), by T. A. Rickard; "Progress in Gold Milling During 1903" (12), by Robt. H. Richards; "A Review of the Cyanide Process in 1903"

(8), by Charles H. Fulton; "Metallurgical Progress in Western Australia" (4), by Alfred James; "General Review of the Lead Industry and Notes on Manufacturing" (9), by W. R. Ingalls; "The Coeur d'Alene District in 1903" (10), by Stanly A. Easton; "Recent Improvements in Lead Smelting" (32), by H. O. Hofman; "The Sudbury Nickel Mines" (2), by A. McCharles; "The Petroleum Industry of California" (2), by C. T. Deane; "Zinc Production and Metallurgy" (44), by W. R. Ingalls; "Review of the General Literature of Ore Deposits" (11), by J. F. Kemp; "Review of Literature on Ore Dressing" (24), by Robert H. Richards.

Diagrams and Tables for Structural Designers.

Reviewed by R. P. Miller,* M. Am. Soc. C. E.

STRUCTURAL DESIGNERS' HANDBOOK.—Giving Diagrams and Tables for the Design of Beams, Girders and Columns, with Calculations Based on the New York City Building Code. By William Fry Scott, M. Am. Soc. for Testing Materials. New York: The Engineering News Publishing Co. Cloth; 6 × 9¼ ins.; pp. 158; 34 tables and 74 figures in the text. $2.

The purpose of this book, as set forth in the preface, is to shorten and possibly eliminate "much of the computation and drudgery which are necessary accompaniments of structural designing." A general acquaintance with the subject-matter of the book is requisite on the part of the reader, as the discussion and analysis of the several topics covered are necessarily meager. This, of course, is true for any book of tables and diagrams.

The work provides, in a large measure, the essentials for the design of structures when not complicated by truss work or other unusual features. The time-saving is to be accomplished by the use of the diagrams, which take up about one-third of the volume. These diagrams are supplemented by tables occupying about an equal amount of space. The remaining third of the volume is devoted to explanations, analyses, and other necessary or desirable information.

In the compilation of the tables and in the development of the diagrams, New York practice, as established by the New York Building Code, has been closely followed, with a few exceptions. The tables and diagrams, too, apply to no particular set of shapes of structural steel, but are adapted to those of the American Association of Steel Manufacturers, and the Fencoyd and Passaic mills. Even some foreign structural shapes are included.

The diagrams are well drawn and, considering the amount of information in some of them, are exceedingly clear. So far, too, as it has been possible to check them they have been found accurate and correct. To any one accustomed to the use of diagrams they should prove valuable. It has, however, always seemed to the reviewer much easier to pick out information from tables than from diagrams and with considerably less chance of error. But a book of tables, covering the same ground, would be much larger, and therefore less convenient for use.

At the very beginning of the work the author introduces a new term, Section-Moment, which he defines as "a quantity obtained by multiplying the maximum allowable fiber stress by the moment of inertia of the cross-section and dividing by the distance of the extreme fiber from the neutral axis." In other words, it is the moment of resistance. The term is a convenient one, and its value, as given in the tables in Chapter VIII., should prove as useful in beam design as has been the coefficient of strength of the steel handbooks.

The subject of beam-work, including floor framing, spandrel beams and grillage beams, is quite thoroughly treated, and occupies nearly one-half of the book. The chapter on floor framing is certainly the most valuable feature of the volume.

In the treatment of grillage beams, only the concentric footing is considered. Two methods of designing are mentioned. The first, which the author states is the one most commonly used, is that in which only the projecting portions of the beams are considered as subjected to bending. The New York building authorities, however, do not consider it a correct method, and insist on the use of the second method, which takes account of the fact that maximum bending moment occurs under the middle of the superincumbent layer of beams. The concrete which may be placed between the beams is not to be relied on for additional strength, as the author himself suggests in discussing the buckling of the web.

In the chapter on cast iron columns a diagram is shown giving the safe loads according to the New York Building Code. The concededly bad practice allowed by the New York Building Code, however, is recognized, for a second diagram is furnished giving the safe loads on cast iron columns as recommended by the author. These loads are about 50 to 70 per cent. of the former, respectively, for the high and low ratios of length to radius of gyration, or, as the author puts it, the ratio of slenderness.

In Chapters X., XI. and XII., treating of loads, unit stresses and brick walls, the New York Building Code is freely quoted. Non-bearing walls, however, in warehouses, are not permitted 4 ins. less in thickness than bearing walls, as stated on page 130. Such reduction is only permitted in "dwelling house walls."

The author includes partitions in the dead load of construction. An extended experience in such matters satisfies the reviewer that partitions should be treated as live load. They are not generally fixed when the structure is designed, and very frequently altered, shifted or extended after the building is occupied.

The live loads given are those specified by the New York Building Code. They vary considerably in some respects from the practice in other cities, and it is a pity that the author did not point out the differences. The usefulness of his book would have been materially increased thereby.

Again, in designing the footings of foundations, the New York practice is followed. The method of designing footings as given by Mr. C. C. Schneider in a recent paper before the American Society of Civil Engineers is a much more rational and safer one, and in no way conflicts with the New York law.

The unit stresses given in Chapter XI. are those of the New York Building Code, with the exception of the allowable compressive stresses for wood across the grain, for which he uses the more conservative values recommended by the Association of Railway Superintendents of Bridges and Buildings.

Too much has been attempted in Diagram 40, giving the thickness and weight of walls for varying heights. It is rarely the case that all the stories of a building are the same height, and the same arrangement is not often repeated. To take the thicknesses and weights from the diagrams, with any reasonable certainty, would require more time than it would take to figure it out from the law. Furthermore, as the author shows on page 130, there are numerous conditions that modify the thicknesses given on the diagram. It should also be pointed out that the height above the foundation wall determines the thickness of a wall, not its height above the curb. A more rational method, however, would appear to be to measure the wall from the top down in fixing its thickness.

No reference is made to what is known in New York, under Section 37 of the Code, as "curtain wall construction." This construction came in for a large share of criticism at the time of the Darlington disaster; though no one has ever contended that the walls had anything to do with the collapse. It is believed, however, that such walls are entirely safe, if the following restrictions of the New York Building Bureau are closely followed:

> The masonry work throughout must be laid in cement mortar. The foundations of the building must be so designed that the load from the columns and the load of the walls are carried together, so that there can be no uneven settlement. The metal ties between columns at each story must not be imbedded in the masonry, and must be set clear of it on the interior. The masonry must be anchored to the floor construction at the end of each line of tie rods or floor beams.

In conclusion, attention should be called to the high class workmanship and typography employed in the production of this volume.

*Chief Engineer, Bureau of Buildings, 220 Fourth Ave., New York City.

Two Electrical Laboratory Manuals for General Instruction.

LABORATORY AND FACTORY TESTS IN ELECTRICAL ENGINEERING.—By George F. Sever, Adjunct Professor of Electrical Engineering, Columbia University; and Fitzhugh Townsend, Tutor in Electrical Engineering, Columbia University. New York: D. Van Nostrand Co. Cloth; 6 × 9 ins.; pp. xii + 220 tables and 97 figures in the text. $2.50, net.

SHORT COURSE IN ALTERNATING-CURRENT TESTING.—By Fitzhugh Townsend, Tutor in Electrical Engineering, Columbia University. New York: D. Van Nostrand Co. Stiff paper; 5½ × 8½ ins.; pp. 82; figures in the text. 75 cts., net.

An excellent manual of electrical machine testing is made available in Sever and Townsend's "Laboratory and Factory Tests in Electrical Engineering." It is more than a manual of tests for many of the experiments are such as instruct in the qualitative rather than the quantitative behavior of machines. Testing in itself, the mere measurement of various elements of a machine may be gone through without any appreciation of the operative qualities of the machine, the qualities which usually define its field of utility and its field of troublesomeness. One may learn how to determine the efficiency curve of an induction motor, and may make the actual measurements, without finding out that the motor may stall under overload, or why it does so. In nearly every course of laboratory tests laid out for students a certain amount of recognition is accorded to experiments of qualitative nature; but in the present manual they have received a really broad and full recognition, both in the selection of tests and in the explanatory and analytical text. Herein lies one of the principal merits of the book, a feature which makes the book of much value outside of the college laboratory class.

The text which is built around the framework formed by the methods and directions for the tests is sufficiently detailed to make the book a condensed text-book on electrical machinery. It is not elementary, in that the simpler description and explanation of the machines is omitted; on the other hand, formulas and theoretical analysis are in general not given. The explanation refers to operation, and formulas or graphical diagrams are given only where needed for this object. The text is very lucidly written, although at some points too concise for ease in reading.

The characteristics above suggested seem to make the book valuable to many who have no opportunities for testing. Most text-books on electrical machinery are inadequate in their discussion of operating peculiarities, a fact which has several times been noted in these columns. Knowledge of such matters is usually obtainable only by individual experience, though much of it could well be learned from books. The present testing manual will prove a good study text for those who have not ample opportunity to become acquainted in detail with electrical machines by personal experience.

The range of the book and its adaptability to its intended use as a manual for laboratory and factory testing may be best judged from a brief summary of the contents. The first chapter deals with resistance tests, temperature coefficient, etc. Dynamo and motor operation (direct current) is the subject of the next four chapters. Then alternating currents are taken up in ten chapters, first circuits in general and later the various a. c. machines, beginning with the generator. A separate chapter on curve tracing is included herein. In the closing chapter, distinct from the preceding, electrical measurements of physical nature are taken up, such as permeability and hysteresis measurements, potentiometer tests, calibration of commercial instruments, etc. This chapter also includes some storage-battery tests and incandescent-lamp tests. The proportionate space given to the three sections of the book is best indicated by the respective number of pages: Direct-current tests, 105 pp.; alternating-current, 74 pp,. and physical measurements, 55 pp.

Mr. Fitzhugh Townsend's "Short Course in Alternating Current Testing" has the same character, in a general way, as the preceding work. Eight sets of experiments are outlined, in each case preceded by a concise discussion of the operating characteristics of the machine in question. They deal with: (1) Properties of circuits; (2) the

...ing current generator; (3) the voltage ... a generator or of a circuit; (4) the trans... (operation, losses and efficiency); (5) the ... motor (operation and efficiency); (6) ...chronous motor (operation and phase ...teristic); (7) the rotary converter (opera... ...en driven from either end); and (8) opera... ...f alternators in parallel.

A French Work on Canal Construction.

...X. (A Course in Inland Navigation at the Ecole ...ionale des Ponts et Chaussées).—By F. B. De Mas, ...pector-General, Professor at the Ecole Nationale ... Ponts et Chaussées. In Encyclopédie des Travaux ...blics, begun by Mr. C. Lechalas. Paris: Ch. ...eranger. Paper; 6½ × 10 ins.; pp. 579; tables, plates ...d figures in the text. 17.5 fr. or $5.25.

...hile in America canals play a small part in ...nland transportation, Continental European ...ountries, generally, have continued to develop ...their early canal systems in conjunction with the ...extension of their railways. It is natural enough, therefore, in a series of volumes designed to cover the engineering of public works from the viewpoint of European practice that a prominent place should be allotted to a volume on canal construction. The volume before us seems to be entirely worthy of the position assigned to it, if we except the important and rather inexplicable omission of any information regarding locks and lock gates of the ordinary type. Mechanical devices for overcoming high lifts in canals are considered in detail, but there is nowhere a bit of information regarding ordinary miter gate lock construction and operation. Even with this serious omission the book is far ahead of anything in English on the subject with which it deals.

The author begins his work with the consideration of cross-section, alinement and profile, and discusses briefly the various legal and physical conditions governing these matters, such as state laws, resistance to the propulsion of boats in narrow channels, the juxtaposition of railways and natural waterways, the relative frequency of special works, such as bridges, culverts, aqueducts and tunnels, and the possible sources of traffic. A particularly good section of this portion of the book is that devoted to the rational determination of transverse section based on resistance to propulsion. Two chapters are devoted to the subjects mentioned, and the two succeeding chapters discuss, first, structures for canal crossings of highways and railways, and, second, structures for canal crossings of streams and waterways. In considering structures for the first purpose, the author classifies them according as the highway or railway crosses above, below or at the level of the canal, and the bulk of the space is devoted to descriptions of movable bridges suitable for crossings at or near the canal level. Several of the structures shown are of novel form, and the whole chapter should prove of interest to American engineers, many of whom may have to rebuild and maintain bridges across existing canals, even though never called upon for canal construction proper.

The second class of structures, those for canal crossings of streams, are subdivided into four classes. The first class comprises culverts and siphons for taking small streams under the canal. Some 20 pages are devoted to descriptions and drawings of these structures. Aqueducts for carrying the canal over streams form the second class, and some 40 pages are given up to describing and illustrating masonry and steel aqueduct construction. Crossings at level are illustrated by the notable examples of the crossings of the Loire canal and the River Loire at Chatillon and at Decize, and the rare case of carrying streams over canals is exemplified by the steel aqueduct which takes the River Oudan over the Roanne canal at Digoin. In discussing aqueduct construction, the author devotes particular attention to ways and means of rendering such structures water-tight, and of securing water-tight junctions between them and the adjacent earth sections which they join.

Chapter V. is an elaborate discussion of works for overcoming high lifts. The author divides such works into lift locks, inclined planes and ship railways. The bulk of the space is devoted to lift locks, and descriptions are given of the locks at Anderton, England; at Fontinettes, France, and at Henrichenburg, Germany, and of the four locks on the new Canal du Centre, in Belgium. A number of European and American inclined planes are similarly described, and there is a brief reference to the several instances where ship railways have been proposed. The chapter closes with a comparison of the advantages of the several methods practiced for overcoming differences in level of canals. The succeeding chapter is devoted to the important question of conserving the water of canals, and it is followed by a long chapter on reservoir dams and barrages. In a final chapter of 85 pages the author discusses the maintenance and operation of canals.

Projective Geometry.

Reviewed by Prof. Virgil Snyder.*

AN INTRODUCTION TO PROJECTIVE GEOMETRY AND ITS APPLICATIONS.—An Analytic and Synthetic Treatment. By Arnold Emch, Ph. D., Professor of Graphics and Mathematics in the University of Colorado. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 267; 114 figures in the text. $2.50.

While the tendency of most recent works on projective geometry is towards the logical side, that is, to develop a system of geometry without resource to analysis or space intention, the applications have been more and more neglected.

A healthful reaction is manifest in the present book; but little attempt is made at rigor (as the word is technically used by mathematicians), but an instrument is placed in the hands of anyone who reads it for solving and generalizing many geometric problems.

The first chapter derives the usual theorems of projective ranges and pencils, perspective and involution by means of the anharmonic ratio. The procedure is essentially analytic, but the geometric interpretation of each step is carefully given. The second chapter deals with collineation; it is shown that such transformations are made up of central projection and motion, and examples show the relation between problems which here arise and those of descriptive geometry. A chapter on the theory of conics contains much of the matter of the usual text-books on analytic geometry, and also various applications of the theory of pole and polar, the theorems of Pascal and Brianchon, and the uses of conics in problems in mechanical drawing. The next chapter discusses the conics which pass through four fixed points, and new loci derived from two such systems projectively related; the cubic curve, defined by a pencil of conics and a projective pencil of lines, is treated at some length, including the circular cubic and the discussion of its possible forms. The fifth chapter, of over forty pages, is devoted to applications to mechanics. After discussing statical proofs of projective theorems, the geometry of stresses in a plane and the realization of collineations by linkages are treated in much greater detail. First the pantograph, Peaucellier's inversor and Kempe's translator are explained, then these instruments are generalized to effect various linear transformations, including perspective.

A knowledge of trigonometry and plane analytic geometry is all that is required to understand the book, which is clearly and carefully written. Numerous references to more ambitious works are given.

A Descriptive Text-Book on Hydrography and Dams.

DER WASSERBAU.—By M. Strukel, Professor of Engineering at the Finland Polytechnic Institute at Helsingfors. Based on lectures held at the Finland Polytechnic Institute. In four volumes. Part I, Origin, Occurrence and Properties of Water; Dams; and Fish Passes. Helsingfors: Förlags A. B. Helios. Paper; 8 × 10 ins.; pp. 198; 103 illustrations in the text and 15 full-page plates appended. Second Edition. 14 reichmarks; American price, $4.20.

A good atlas of sketches and drawings, appended to the text of this volume, represents its characteristic feature. The work is a descriptive text-book relating to hydrology and hydrography, and the design of dams and fish-ladders. The author draws his material from all parts of the world, though, of course, his viewpoint is European. The book does not cover a complete and unified subject, as may be judged from the above characterization; but this is in part due to the fact that the book is only a fragment of a larger work, being Part I. of a four-volume treatise on Hydraulic Construction.

The contents of this volume are, in their actual order: Circulation of Water, Rainfall, Evaporation, Seepage and Ground Water (20 pp.); Surface Water (54 pp.), including the measurement of run-off, stream discharge, velocity, etc.; Weirs or Overfall Dams (70 pp.), which include all forms of movable dams; Dams proper (25 pp.), which include earth embankments, masonry, fill, steel, concrete, and composite dams; and lastly, Fish Passes (25 pp.).

Special attention is devoted to actual construction, of instruments and structures; each chapter and subdivision closes with a series of descriptive paragraphs referring to illustrations given in the appended atlas, or in some cases to illustrations in the text. Representative structures are shown, and the principal statistical facts, dates, etc., given in the descriptive notes. Any value which the work may have for American readers will lie in this descriptive portion and its illustrations. Presumably the compilation of facts has been made with the care that characterizes the best European treatises. In the description of the New Croton Dam of the New York City water supply we note that only the original design is referred to, in which a part of the structure was earth embankment. The change to full masonry construction appears to have been overlooked in editing the second edition.

*Department of Mathematics, Cornell University, Ithaca, N. Y.

Road-Making.

THE FUTURE OF ROAD-MAKING IN AMERICA.—A Symposium by Archer Butler Hulbert and others. Being Vol. 15 of Historic Highways of America. Cleveland, O.: The Arthur H. Clark Co. Cloth; 5½ × 7½ ins.; pp. 211; nine plates. Complete in 16 volumes. In sets only. $30 net.

It is surprising to have fourteen volumes on the historic highways of America, from buffalo runs and Indian trails to railways, followed by one on the present and future of ordinary road-making, but the conception of the present volume is in keeping with the sociological aspects of the series.

The editor occupies nearly a third of the book with the title-subject, pointing out the miserable condition of a large part of our road mileage and the relation of good roads to social, educational and financial progress. "Government Co-operation in Object Lesson Road Work" and "Good Roads for Farmers" are reviewed in turn by Messrs. Martin Dodge and Maurice O. Eldridge, Director and Assistant Director, respectively, of the U. S. Office of Public Road Inquiries. Most of the contents of these sections has a familiar sound to the readers of "Good Roads" literature, particularly the many quotations from Mr. Isaac Potter, but it is to be hoped that the volume will go into the hands of many to whom its contents will be new.

By far the best and most needed twenty pages in the book, from our viewpoint, is "The Selection of Materials for Macadam Roads," by Mr. Logan Waller Page, who is in charge of the Road Material Laboratory, Division of Chemistry, U. S. Department of Agriculture. An equally brief section, which may also be commended, is "Stone Roads in New Jersey," by E. G. Harrison, C. E., Secretary New Jersey Road Improvement Association.

The volume might well have been expanded, or else some of the space in the first and third sections given up, to include more information about road improvements in Massachusetts, Connecticut, New York and perhaps some other states. The Connecticut attempt to extend good road work into the poorer and more thinly populated towns might well have been described.

THE SANITARY JOURNAL OF THE PROVINCIAL BOARD OF HEALTH, ONTARIO.—Parts I. and II. of the Report for 1904. Toronto, Ont.: C. A. Hodgetts, Secretary. Paper; 6 × 10 ins.; pp. 53; tables.

Hereafter a quarterly of the name given above will take the place of the usual annual report, the monthly bulletin and the yearly report of the Executive Health Officers' Association. Laboratory reports will be prepared by Dr. J. A. Amyot, Bacteriologist to the board, who, in the present Journal, writes on "Interpretation of an Ordinary Water Analysis for Hygienic Purposes."

Suction Gas Producers.

Reviewed by Alfred E. Forstall.*

SUCTION GAS.—By Oswald H. Haensgen. Cincinnati: The Gas Engine Publishing Co. Cloth; 5 × 7¼ ins.; pp. 88. $1.

Written, according to the author, to supply the lack, in this country, of information on the subject of suction gas producers, this little book treats clearly and in some detail of the design and operation of such producers, and more briefly of their first cost, cost of running and possible utility and development.

Producers of this type are of comparatively recent origin, and have been designed to meet the demand for a simpler, cheaper and more compact apparatus than the ordinary producer plant for the supply of gas for motive power. These advantages are obtained by dispensing with the boiler and gas holder required by forced draft producers, and calling upon the gas engine itself to furnish, by means of the suction exerted by the piston as it travels out on the charging stroke, the power needed to carry through the fuel bed the air and steam necessary for the partial combustion of the fuel, this suction being transmitted through the whole apparatus. Gas is thus made only when, and in the quantity, required by the engine.

Although such producers have not been used to any great extent in this country, having been developed in Europe, and being subject here to greater competition from cheap liquid fuel, they would seem very useful in connection with gas engine installations of from 50 to 100-HP.

A TEXT-BOOK ON ROOFS AND BRIDGES.—Part I.: Stresses in Simple Trusses. By Mansfield Merriman, Professor of Civil Engineering in Lehigh University, and Henry S. Jacoby, Professor of Bridge Engineering in Cornell University. Sixth Edition, Rewritten and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 316; two folding and 24 full-page plates and 101 figures in the text. $2.50.

Those of our readers who are familiar with the first edition of this book, published in 1888, will hardly recognize the present volume as being a revision of the same book. Indeed, after the first chapter, Stresses in Roof Trusses, is passed the remainder of the book is a new work in volume, arrangement and contents. To be specific, the book has been enlarged from 191 to 326 pages, and the former classification for bridges has been replaced by one involving loads. We now have the dead load stresses, the live load stresses and the stresses due to wind and other causes treated in separate chapters for the common forms of simple trusses. The fifth chapter takes up the consideration of long span bridges, and here we find an unusual amount of historical matter relating to early American long span bridges and an interesting tabulation of the various long span simple trusses that have been built in the United States. Chapter VI. discusses portal bracing, sway and lateral bracing and plate girder design. Chapter VII. treats of deflections and presents the theory that the economic depth of truss is closely the one which gives the greatest stiffness. The final chapter takes up cranes, bents, towers, viaducts and other miscellaneous structures. A notable feature of the new edition is the extensive use of illustrations, including half-tone views of notable truss bridges, folding plates and numerous text drawings.

RECHERCHES EXPERIMENTALES SUR LA CONSTITUTION DES MORTIERS HYDRAULIQUES.—By M. H. LeChatelier, Ingénieur en Ches des Mines. Second Edition. Paris: Dunod. Paper; 6½ x 10 ins.; pp. 196.

In a thesis for his doctorate presented to the Faculty of Sciences of Paris in 1887, M. H. Le Chatelier gave the results of a study, from a chemical and mineralogical point of view, of the various combinations of lime, silica and alumina; determined their character, and, finally, endeavored to recognize the presence of one or another of them in hydraulic cement. In 1893 these original studies were supplemented by a second set of experiments, the results of which were published in "Annales des Mines" for that year. These two communications gave to scientists their first exact knowledge concerning the constitution of Portland cement, and a reprint of them forms the bulk of the text of the book before us. Since Le Chatelier published the results of his latest investigations in 1893, the constitution of Portland cement has been studied experimentally in Sweden by Mr. A. E. Tornebohm, in 1897, and in America by Messrs. Spencer B. and W. B. Newberry in 1897, and by Mr. Clifford Richardson in 1904. The work of these later experimenters has disproved some of the conclusions reached by Le Chatelier, and has corroborated others of them, so that now they are far from being the absolute authority that they once seemed to be. As a record of the first widely accepted theory of the constitution of hydraulic cement and of the methods by which this theory was arrived at, these papers are, however, of wide interest to students of the chemistry of cements, and the present reprint puts them in convenient form for use. In addition to the two main papers the book contains summaries of the results of recent investigations regarding the roles played in cements by chloride of calcium, sulphate of lime and magnesia; studies relating to accelerated tests, expansion during setting and hardening, and disintegration by sea water.

*Consulting Engineer, late Secretary American Gas Light Association, 58 William St., New York City.

Geological Survey Reports.

MINERAL RESOURCES OF CANADA.—Geological Survey of Canada. Robert Bell, D. Sc., F. R. S., Acting Director. Ottawa: Pub. Doc. Paper; 6½ × 9½ ins. Apatite (pp. 32); Asbestos (pp. 28); Graphite (pp. 30); Infusorial Earth (pp. 14); Manganese (pp. 27); Mica (pp. 32); Molybdenum and Tungsten (pp. 16); Peat (pp. 40); Platinum (pp. 26); Salt (pp. 33); Zinc (pp. 13).

MARL DEPOSITS IN ONTARIO, QUEBEC, NEW BRUNSWICK AND NOVA SCOTIA.—By R. W. Ells, LL. D., F. R. S. C. Published by permission of the Director of the Geological Survey of Canada. Paper; 6 × 9 ins.; pp. 11.

These bulletins present in concise form an excellent description of the mineral resources of Canada. They are not verbose. They make no attempt at long drawn out speculation as to the origin of mineral deposits. But they do give a clear idea of where valuable deposits occur and the extent to which those deposits are being worked.

MINERAL RESOURCES OF THE UNITED STATES, CALENDAR YEAR 1903.—By David T. Day, Chief of Division of Mining and Mineral Resources, U. S. Geological Survey. Washington, D. C.: Pub. Doc. Cloth; 6 × 9 ins.; pp. 1,204; tables.

THE PRODUCTION OF COAL IN 1903.—Extract from Mineral Resources, etc. Paper; 6 × 9 ins.; pp. 192.

PRODUCTION OF GAS, COKE, TAR AND AMMONIA AT GAS WORKS AND IN RETORT COKE OVENS IN 1903.—Extract from Mineral Resources, etc. Paper; 6 × 9 ins.; pp. 30.

STATISTICS OF THE AMERICAN IRON TRADE FOR 1903.—Extract from Mineral Resources, etc. Paper; 6 × 9 ins.; pp. 57.

THE STONE INDUSTRY IN 1903.—Extract from Mineral Resources, etc. Paper; 6 × 9 ins.; pp. 208.

The arrangement and scope of the matter in this volume are essentially the same as in the 19 preceding reports of the series of the Mineral Resources of the United States. As heretofore, the publication of this volume has been anticipated to a great extent by the advance issue, in pamphlet form, of the several chapters that compose it. The pamphlets, or chapters, that will particularly interest civil engineers are as follows: The Stone Industry, The Production of Coal, of Iron, of Cement, Clay-working Industries, Steel Hardening Metals, and Mineral Paints.

BULLETINS U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 6 × 9 ins.

No. 235: A Geological Reconnaissance across the Cascade Range near the Forty-ninth Parallel. By George Otis Smith and Frank C. Calkins. Pp. 103; four plates and one figure.

No. 237: Petrography and Geology of the Igneous Rocks of the Highwood Mountains, Montana. By Louis Valentine Pirsson. Pp. 208; 7 plates and 8 figures in the text.

No. 239: Rock Cleavage. By Charles Kenneth Leith. Pp. 216; 27 plates and 40 figures in the text.

No. 254: Report of Progress in the Geological Resurvey of the Cripple Creek District, Colorado. By Waldeman Lindgren and Frederick Leslie Ransome. Pp. 36.

The bulletin on Rock Cleavage contains the results of a systematic microscopical study of cleavage of all kinds from many localities, the purpose of the author being to ascertain the exact arrangement of the mineral particles, the relation of this arrangement to cleavage, and the relation of cleavage to the deformation of rock. Based upon his observations, the author presents general conclusions as to the origin and conditions of cleavage. The other bulletins demand no comment here.

U. S. GEOLOGICAL SURVEY.—Report for 1903-4. Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Cloth; 8 × 12 ins.; pp. 388; 25 plates and two figures in the text.

As usual, this report is made up of a general review of the work of the year. The Hydrographic Branch and the Reclamation Service receive a good share of attention, the work of the latter being reviewed by States.

SKETCH PORTFOLIO OF RAILROAD STATIONS.—From Original Designs. By Bradford L. Gilbert. Fifth Edition (1895), with Supplement (1904). New York: The Railroad Gazette. Cloth; 13 × 10 ins.; pages not given; many illustrations. $3.25.

The title of this book is a fair description of its contents. The author has collected here engravings, consisting mostly of perspective views of a large number of railway stations designed by himself and erected in various parts of the United States. The views include stations of all sizes, and each is accompanied by a caption explaining the main features of the structure shown.

STATE BOARD OF HEALTH OF RHODE ISLAND.—Report for the year ending December 31, 1900, including the report upon the registration of births, marriages and deaths in 1899. Providence, R. I.: Gardner T. Swarte, M. D., Secretary. Cloth; 6 × 9 ins.; pp. 312; tables and diagrams.

STATE BOARD OF HEALTH OF CONNECTICUT.—Report of the Year 1904, with the Registration Report for 1903 Relating to Births, Marriages, Divorces and Deaths. New Haven, Conn.: Charles A. Lindsley, M. D., A. M., Secretary. Cloth; 6 × 9 ins.; pp. 286; tables and diagrams.

These two reports, although covering periods four years apart, were published within a day or so of each other. Why one state should be so very dilatory when the other one is reasonably prompt we will not undertake to explain, but it

TRAUTWINE'S
CIVIL ENGINEER'S POCKET BOOK

18th Edition, 1904
$5.00

JOHN WILEY & SONS
Scientific Publishers
43 and 45 East Nineteenth Street
NEW YORK CITY

a pity to hold vital statistics for 1899 until before publishing them.

Rhode Island report contains chemical and bacterial analyses of the public water supplies of the state for 1900, and like analyses of sewage-works effluents. The Connecticut report contains a number of accounts of typhoid outbreaks, and a report, with analyses, on river pollution and water supplies, the latter being by Prof. Herbert E. Smith, M. D.

Pioneer Irrigation and Railways.

PIONEER IRRIGATION.—A Manual of Information for Farmers in the Colonies. By E. O. Mawson, M. Inst. C. E., Executive Engineer, Public Works Department, Bombay. With Additional Chapters on Light Railways, by E. R. Calthrop, M. Inst. C. E., M. Inst. M. E. London: Crosby Lockwood & Son. Cloth; 5½ x 8½ ins.; pp. 200; 39 plates and 91 figures in the text. 10s. 6d. or $4.20.

Intelligent and enterprising farmers who wish to post themselves on some of the minor engineering features and on the cultural phases of irrigation will doubtless find this book of value. It might also be of service to engineering students, or as a first book to engineers who wished to read up on irrigation. Sources of water supply, dams, canals, automatic sluice gates, methods of irrigation and the cultivation of irrigated crops and fruit trees are considered. Separate treatment is given to underground water supplies and pumping. In the short chapter on Sewage Irrigation it is stated that "septic tanks will work for years without being cleaned," which is true under some conditions and untrue under others. An appendix contains a variety of tables and other useful information, including sizes and (British) prices of materials used in irrigation. The illustrations include an unnecessary number of wash drawings of imaginary irrigation works.

The chapter on "Light Railways," by Mr. E. R. Calthrop, will amuse much more than it will instruct American engineers. Mr. Calthrop's idea of a light railway is a line of either 2-ft. or 2-ft. 6-in. gage. In other words, it is the old narrow-gage fallacy of thirty years ago over again. American engineers, familiar with the work done in this country in building standard-gage lines of low cost will be entertained to read the following by Mr. Calthrop:

> In easy country the cost of a 2-ft. 6-in. gage railway may average one-fourth that of the normal gage; but in rugged mountainous country the difference may be very much greater, the normal gage costing perhaps eight or ten times as much as a narrow gage line.

Elsewhere Mr. Calthrop estimates the average cost of a 2-ft. 6-in. gage railway with 35-lb. rails at $10,000 per mile, as a minimum under the most favorable conditions, to $15,000 per mile in undulating country where an average amount of earth work is required. With 25-lb. rails, and 2-ft. gage, and the maximum load per axle reduced to 3 tons, the cost may be brought down in the most favorable country he says to from $6,000 to $7,500 per mile.

It would doubtless surprise Mr. Calthrop to know that American engineers have built standard-gage roads at a cost per mile not very far from the figures which he gives for these narrow-gage roads.

It is very clear that Mr. Calthrop obtains his exaggerated ideas as to the economy of the narrow gage over the standard simply from adhereing to the old-time English notions concerning the limits of grade and curvature on standard-gage lines. He states the advantage of the narrow gage over the standard as follows:

> The principal savings in capital cost attained by narrowness of gage occur through the much greater flexibility of its alinement due to the power of employing, where necessary, curves of a much smaller radius than can be used on a railway of normal gage. Such flexibility permits a railway of 2-ft. 6-in. gage and under to follow the natural contours of the ground in moderately difficult country, and by thus winding in and out, deep cuttings, heavy embankment and the severance of valuable property can be avoided.

Now let us see what curves and grades Mr. Calthrop proposes to attain by his narrow gage. We quote again as follows:

> In the case of light railways of 2-ft. 6-in. gage, an easy line will have gradients of 1 in 100 against the greater load and 1 in 80 with it, both combined with curves of not less than 600 ft. radius (9° 33'). A very difficult line will have gradients 1 in 30 against the greater load and 1 in 25 with it both combined with a minimum curve of 300 ft. radius (19° 10'). In extraordinarily difficult country and with especially designed rolling stock the gradients may be 1 in 25 (4%) in both directions with curves of 100 ft. radius (60°).

It would evidently be a liberal education for Mr. Calthrop to see the grades and curves of some American standard gage railways which have been built for light traffic in difficult country.

Sanitary Papers.

THE EPIDEMIC OF TYPHOID FEVER AT ITHACA, N. Y.—By George A. Soper, Ph.D. Reprinted from the Journal of the New England Water-Works Association, Vol. XVIII., No. 4 (Dec., 1904). Paper; 6 × 9 ins.; pp. 31; eight plates. (Send stamp to author at 29 Broadway, New York City.)

Since for some inscrutable reason the New York State Department of Health did not publish Dr. Soper's exhaustive official report as representative of the department at Ithaca for several months during the great typhoid epidemic of 1903, there is all the greater reason to be thankful to the New England Water-Works Association and to Dr. Soper for this valuable paper. The Ithaca epidemic was one of the worst on record, and it was observed and reported by Dr. Soper with unusual care. The official report might well have been published in a large edition and widely circulated as a warning to other communities to protect themselves against a similar calamity.

THE RELATION OF PREVENTABLE DISEASE TO TAXATION.—By Henry B. Baker, M. D., Committee of the State Board of Health on that subject. Lansing: Michigan State Board of Health, February, 1905. Paper; 6 × 9 ins.; pp. 16; 12 tables.

We have here a valuable analytical study of local expenditures in Michigan during 1903 on account of indigent sufferers from dangerous communicable diseases; also computations of the money values of the lives apparently saved in 1903 through the lowered death rate from smallpox, typhoid fever, scarlet fever and consumption since the organization of the State Board of Health. The aggregate estimated value of these saved lives is several times as great as the total expense of caring for indigent sufferers from all the communicable diseases listed. There are many fallacies, some of which the author points out, in a comparison of this kind. The permanent and general value of Dr. Baker's study lies in calling attention to the decreased death rates from certain communicable diseases, and particularly in showing how the expenditures for the indigent sick are distributed among the different communicable diseases and also between doctors, nurses, watchmen, vaccination, antitoxin, disinfectants and other purposes. Smallpox consumes $118,149 of the $222,392 expended, consumption only $1,127, pneumonia only a petty $5. As the author points out, the public does not fear consumption and pneumonia as it does smallpox. Pneumonia causes more deaths in Michigan than any other communicable disease, and consumption comes next; yet little is being done for sufferers from either.

THE PURIFICATION OF WATER FROM A SANITARY STANDPOINT.—By Freeland Howe, Jr. Pittsburg, Pa.: Pittsburg Filter Manufacturing Co. Paper; 6× 9 ins.; pp. 16.

MECHANICAL FILTRATION.—By Freeland Howe, Jr. Pittsburg, Pa.: Pittsburg Filter Manufacturing Co. Paper; 6×9 ins.; pp. 21.

Bearing in mind that promoting the use of mechanical filters is the primary object of these pamphlets, and making allowances accordingly, they may be accepted as satisfactory outlines of the subjects presented.

PROGRESS REPORT OF COOPERATIVE IRRIGATION INVESTIGATIONS IN CALIFORNIA.—By S. Fortier, Irrigation Engineer, in charge of Pacific District. Circular No. 59, Office of Experiment Stations. A. C. True, director. Washington, D. C.: U. S. Department of Agriculture. Paper; 6×9 ins.; pp. 23; tables.

One of the most interesting lines of work here described is an investigation of pumping water for irrigation, by Prof. J. N. Le Conte, of the University of California, and others. Thus far descriptions of 750 pumping plants have been secured. Both field and laboratory tests of pumping plants have been made. These are here summarized briefly, but will be reported on more fully at a later date. Studies of evaporation and of methods of applying water to land are also described in the pamphlet. The studies are being made at the joint expense of the United States and the State of California.

PROCEEDINGS OF THE RAILWAY SIGNAL ASSOCIATION.—Bethlehem, Pa.: H. S. Balliet, Secretary. Paper; 6 × 9 ins.; pp. 165; illustrated. 25 cts.

This volume covers the several meetings during 1904. The principal subjects of the committee reports are as follows: Wire for pole lines; Circuits for the manual block signal system; Circuits for automatic block signal systems for steam and electric railways; Standard specifications for mechanical interlocking and material for construction work. There are two papers by Dr. N. M. Black on "Comparative Tests of Roundels from an Ophthalmologist's Standpoint," and a paper by Mr. J. B. Struble, on "Alternate Current Signaling." In addition there are discussions of a number of topics.

AN ECONOMIC IMPROVEMENT IN RAILWAYS.—By H. W. Perry. Trichinopoly, India: The Author. Paper; 5¼ × 8½ ins.; pp. 59.

RAILWAY TRACK WITH COMPOUND RAILS.—By H. W. Perry. Trichinopoly, India: The Author. Paper; 6½ × 8¼ ins.; pp. 32.

The improvement in railways suggested is the use of flat cars and removable sectional bodies or boxes instead of the ordinary types of freight cars. The author's idea is to reduce empty-car mileage and to facilitate traffic, but the idea seems to be impracticable and the distribution and collection of the boxes at every station would involve great confusion. The pamphlet is composed largely of letters written by the author describing his system.

The rail suggested by Mr. Perry has a permanent web and base formed of two special angles riveted back to back and breaking joint. The height is 8 ins., and the width of base 14 ins. The top of the web is widened and supports a channel-shaped rail head, 3 ins. wide and 2 ins. deep, which is apparently attached to the web simply by the friction of a tight fit. Any fastening seems to be considered unnecessary, but the practical efficiency of such a system is open to doubt. An alternative design with bolted cap or rail head is shown. It is proposed to eliminate the use of ties, laying the rails on sand cushions on concrete longitudinals, and to fill in concrete between the permanent rail webs or girders, the webs being connected at intervals by tie bars.

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Automobile Designing.

Reviewed by Professor Storm Bull.

PETROL MOTORS AND MOTOR CARS.—A Handbook for Engineers, Designers and Draftsmen. By T. Hyler White, Assoc. M. Inst. M. E. London, New York and Bombay: Longmans, Green & Co. Cloth; 5½ × 8 ins.; pp. 187; many tables, two plates and 42 figures in the text. $1.40 net; $1.50 by mail.

The author states in his preface that this book has been written especially for the designers of automobiles, the reason being that although a good many books have been written about automobiles in the last few years, yet no book had been produced which could be of very much service to the designers of these vehicles.

That this object has been kept steadily in view is very evident on examination of the book. Practical rules for the design of the more important parts of the motor and of the motor cars are given and most of the designs are illustrated by figures. The formulas which are given seem to be of a rational nature; but to the reviewer it seems a fault that the derivation of the same are never given. It is evidently expected that designers shall apply the author's formulas without questioning their correctness or applicability to the particular case. This seems a good deal like rule of thumb work and may be the manner in which such work is done to a very large extent in Great Britain; but it will hardly answer for other countries. This book is not a mechanical engineer's pocket-book in which for want of space the derivation of formula must be omitted, but it is a monograph in which no such limit of space exists. The author states that he has left the derivations out advisedly, and it is because of this fact that it seemed necessary to say so much about it.

The reviewer has applied a number of the formulæ to special examples and the results have been fair, average values for the particular part in question, so that, no doubt, the formulas are based on an extended practice. It is also evident from other reasons that the author must have had a large experience in the design of automobiles, so there cannot be any doubt that the book should prove very useful to a great many people. It would, however, seem that some subjects occupy altogether too much space as compared with others; for instance, the subject of gearing, in which all the profiles of teeth which are used in automobiles are given. These profiles are not different from those used in other machines and consequently all the necessary information in this line can be found in the handbooks on Machine Design, so that a good deal of space could have been saved here.

The author discusses at various places the several alternatives for the many parts of a modern automobile; he gives his reasons for his choice very clearly and never uses superfluous words, for which fact he deserves praise. Of course it ought not to be necessary to state that it is not always possible to agree with his conclusions.

The author seems quite familiar with American practice, and he has made good use of it in his book. But the title of the book is alone sufficient to show that he is an Englishman who, in this instance, however, is not quite so "insular" as so many of his countrymen. About thirty pages of the book are filled with various tables, the first part of which are of the kind given in pocket-books to facilitate calculations. There are also a large number of tables for the conversion of English units into metric measures, and vice versa. These latter tables are very complete and should be very useful if one has anything to do with motors built on the continent of Europe or if one wishes to compare motors built in the various countries.

The illustrations of the book are very good, although it would seem that their usefulness would have been very much increased if the dimensions of the various parts had been given or if they had been drawn to scale and this scale given. The illustrations are so few that the designer has hardly any choice at all, should he be limited to the illustrations given in the book. In this respect the book is greatly inferior to Gueldner's book,* which possesses a wealth of illustrations nearly all provided with dimensions. But it should of course be remembered that the latter book covers the whole field of gas and gasoline engines, whereas Mr. White's book is limited to gasoline engines used for automobiles. As a book for the special purpose of helping the designers of these engines it appears to the reviewer that it is the best existing book in the English language, notwithstanding the criticisms which have been made above.

*Das Verbrennungsmoteren; reviewed by Professor Bull in this Supplement for May 14, 1903.

ELEMENTARY COURSE IN MECHANICAL DRAWING. For Manual Training and Technical Schools. Comprising Selections and Use of Instruments, Geometrical Problems, Orthographic Projections, and Shades and Shadows. With Chapters on Machine Sketching and the Blue Printing Process. By Arthur W. Chase, B. S. In Two Parts: Part I. Chicago, Ill.: Howland Speakman. Cloth; 8½ × 7 ins.; pp. 189; 97 figures in the text. $1.50.

As its title implies, this work presents in the usual style an introduction to the elements of mechanical drawing. The problems have been arranged so as to omit all finished sheets; the student is given the layout of a drawing only; in this way any direct copying of finished work is prevented. Specifications are fully given in every case, so the student receives a drill similar to the experienced in practical work. The text is lucidly but not always concisely written. The illustrations are plain and fairly well executed.

THE FUNCTION OF MASONRY IN MODERN ARCHITECTURAL STRUCTURES.—By R. Guastavino. Part II. New York: The Author, 49 E. 19th St. Paper; 6 × 9 ins.; pp. 91.

In transmitting this book for review the author writes:

The idea of the work is principally to impart to beginners in architecture the fundamental principles of properly utilized masonry to protect perishable materials; and why and wherewith to protect the setting of cement as well as its disintegration by fire, which can only be accomplished by using burnt clay, following some pertinent metaphysical considerations to modern noble masonry work.

We do not feel that we can add anything of value to this characterization.

PROGRESS REPORT ON THE STRENGTH OF STRUCTURAL TIMBER.—By W. Kendrick Hatt, Ph. D. Circular No. 32, U. S. Bureau of Forestry. Washington, D. C.: Pub. Doc. Paper; 6 × 9 ins.; pp. 28.

This report gives tests on the following species of timber: The Pacific Coast red fir, known also as Oregon pine or Douglas spruce; western hemlock; red gum; longleaf pine, and loblolly pine. Some excellent data are contained in the report, of which an abstract will be given in a subsequent issue of this journal.

THE OTTAWA IMPROVEMENT COMMISSION.—Report of Chairman to the Commissioners. Paper; 13 × 10 ins.; pp. 3; 25 half-tone plates, including photographs of Commissioners.

Various street, avenue and driveway improvements and some landscape work in Ottawa have been carried out under this commission, and are here illustrated by means of large half-tone views. Some of the finest of the natural and artificial scenery is marred by telegraph or telephone poles and wires. The commission was created in 1899 and has expended $391,000. Mr. Robert Surtees is consulting engineer; Mr. Henry N. Bate, Chairman, and Senator F. T. Frost, of Smiths Falls Ont., is one of the members.

BI-MONTHLY BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.—Published by the Institute, S. W. Corner Seventh and Cherry Sts., Philadelphia. Paper; 6 × 9 ins.; pp. 265; tables, plates and figures in the text.

Instead of sending out separate papers once in two months, the institute now begins to bind the papers in the form of a bi-monthly publication. A small stock of single papers will be kept for special requirements. Among the papers in this issue are "The Application of Dry-Air Blast to the Manufacture of Iron," by James Gayley, and "The Influence of Carbon, Phosphorus, Manganese and Sulphur on the Tensile Strength of Open Hearth Steel," by H. H. Campbell.

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Literary Magazines.

"The Everglades of Florida" is the title of a very interesting paper in the February "Century." Few realize that the southern portion of Florida is the largest area of practically unknown and almost unexplored land within the limits of the United States. It is really a vast shallow lake, so shallow that from the bed of muck in its bottom sawgrass grows and covers the whole region so that from a distance it looks like a prairie. But this growth of grass prevents navigation by boats while the depth of the water and the mud makes travel otherwise all but impossible. Three or four exploring expeditions have crossed the Everglades; but have done so with no small risk of life. While in the popular mind the region is supposed to be a swamp, dense with miasmatic poison, the writer of the article declares that the water of the glades is clear, pure and palatable, without the least suggestion of staleness or stagnancy, the air is fresh and full of ozone and mosquitoes are not found in the interior of the glades. Venomous snakes, however, are so numerous as to make the path of the explorer a very dangerous one. The great region extends some 100 miles east and west and over 200 miles from north to south. It is quite within the possibilities that at some future day it will be drained and made fit for cultivation.

"The Century" also contains a very interesting account of Chicago's work in park development by Henry G. Foreman, President of the South Park Commissioners of Chicago. Mr. Foreman claims that when its park system as now planned is completed, Chicago will lead all American cities in its park area and applied facilities.

The February "Review of Reviews" opens with a paper on the Panama Canal by Hon. John Barrett, Minister to Panama. The article is particularly notable for its praise of Chief Engineer Wallace. We quote as follows:

> As an entirely impartial observer, connected in no way with the Canal Commission, I beg of the American people to have every confidence in Chief Engineer Wallace, and to trust him to the fullest extent to complete the canal successfully, despite all obstables. The government at Washington, and Congress, however, have a grave responsibility in equipping him or the commission with sufficient authority, so that he may not be held back and delayed, as he now is, by certain unfortunate features of organization and responsibility.

Mr. Barrett then points out that the newspapers are wholly wrong in supposing that Mr. Wallace has advocated the construction of a sea-level canal at Panama, since Mr. Wallace has actually made no report nor has he publicly gone on record in any way as advocating either a sea-level or a lock canal. Having said this, Mr. Barrett proceeds on his own account to discuss the question as to the type of canal that should be built and comes out strongly for the sea-level canal, claiming that it could be built for not more than $50,000,000 more than the lock canal and in not more than ten years from Jan. 1, 1904. As it may interest our readers especially to see how the time estimate is arrived at by Mr. Barrett, we quote the following:

> How much time will be required to excavate the Culebra, or central, division so that vessels drawing 25 to 30 ft. can pass safely through? From thorough tests, Mr. W. E. Dauchey, the engineer under Mr. Wallace in charge of Culebra and formerly chief engineer of the Rock Island Railroad system, has demonstrated that the steam-excavators which are now at work in the Culebra cut can handle 25,000 cu. yds. per machine per month, working 10 out of 24 hours for 25 days in the month. This means an average of 360,000 yards per annum for each machine. If we make a liberal reduction of 50,000 yards for time when the machine is idle through repairs, rains, slides, etc., we can place this estimate at 310,000 cubic yards. Now, then, if two machines are placed every half-mile of the section, one on each side of the cut, for a distance of eight miles, allowing for the gradual slant on both sides, we have 32 machines excavating 9,920,000 cubic yards a year. As there are 100,000,000 cubic yards to be excavated in the Culebra division for a sea-level canal, we have approximately ten years required in which to do the work. Two years added for all kinds of contingencies makes twelve. The question now arises, How is the sea-level canal, then, to be finished by January, 1914, or less than ten years, from now?

Without taking space for Mr. Barrett's answer in detail, we may note that what he proposes is to build a dam at Gamboa to develop 25,000 to 50,000 HP. and generate electric current to operate all the canal machinery and light it so that work can be carried on night and day.

Concerning the dams on the canal, Mr. Barrett says "that the technical investigations of the engineers have practically eliminated all these except the dam at Gamboa."

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Other articles of interest to the engineer in the "Review of Reviews" which we can do no more than list here are "Venezuela's Industrial and Commercial Outlook," "Street Railway Fares in the United States," and "The Manhattan Bridge; a Lesson in Municipal Aesthetics."

The United States expedition to the capital of Abyssinia is described in the February "World's Work" by Consul-General Robert P. Skinner, who was the head of the expedition. This country is soon to be opened to civilization by the completion of the railroad from Djibouti, on the Red Sea, nearly opposite Aden, to the capital at Addis Abada, which is now a 22 days' journey by caravan from the present terminus of the railway line at Diré-Douah. Another "World's Work" paper describes the development of Fresno County, California. Thirty-two years ago there was one single house in Fresno, in the central desert of California and its inmates lowered themselves into a well 40 ft. deep dug under the house to escape the heat in the middle of the day. In the whole desert there was not one spot of green. To-day this same spot is the center of a community of 8,000 prosperous families. Its grape vines produce 12,000,000 gallons of wine and nearly 100,000,000 lbs. of raisins; and a large dairy industry and diversified fruit farms have come into existence.

Progress in wireless telegraphy is summarized by Mr. Eugene P. Lyle in still another "World's Work" article. He declares that already wireless telegraphy has become an important factor in enabling steamers approaching each other to keep clear and avoid the chances of a collision. However, the danger of collision with sailing vessels or other craft unequipped with wireless telegraph instruments still remains.

"Railway Rates" are discussed by W. Morton Grinnell in the February "North American Review," in a paper the aim of which is to show that the rates now charged by railways are no more than a fair return on the capital invested.

"Everybody's" for February opens with a description of the dressed beef trust, which the writer, Mr. Chas. Edward Russell, calls "the greatest trust in the world." The paper is particularly interesting at this time when the influence of preferential railway rates and the ownership of private car lines in fortifying monopolies is a subject of such general discussion.

Publications Received.

AMERICAN TOOL MAKING AND INTERCHANGEABLE MANUFACTURING.—A Treatise upon the Designing, Constructing, Use, and Installation of Tools, Jigs, Fixtures, Devices, Special Appliances, Sheet-Metal Working Processes, Automatic Mechanisms, and Labor-Saving Contrivances; together with Their Use in the Lathe, Milling Machine, Turret Lathe, Screw Machine, Boring Mill, Power Press, Drill, Sub-Press, Drop Hammer, etc., for the Working of Metals, the Production of Interchangeable Machine Parts and the Manufacture of Repetition Articles of Metal. By Joseph V. Woodworth. New York: The Norman W. Henley Publishing Co. Cloth; 6 x 9 ins.; pp. 535; 601 figures in the text. $4.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.—Proceedings of the Second Regular Meeting, Held at Cleveland, O., November, 1904. New York: G. P. Conard, Secretary, 24 Park Place. Paper; 6 x 9 ins.; pp. 104.

BRITISH PROGRESS IN MUNICIPAL ENGINEERING.—A Series of Three Lectures by William H. Maxwell, Assoc. M. Inst. C. E., Borough and Water-Works Engineer, Tunbridge Wells Corporation; Author of "Refuse Destructors," "Construction of Roads and Streets," etc. (1) General—Road Engineering and Maintenance. (2) Main Drainage, Sewage Disposal, Destructors. (3) Water Supply—Conclusion. Being Volume I. of National Engineering and Trade Lectures, Edited by Ben. H. Morgan. London: Archibald Constable & Co., Ltd. Boards, with Paper Labels; 7 x 10½ ins.; pp. 182; 214 illustrations on folding and full page plates. 6 shillings, net; American price, $2.40.

CYCLOPEDIA OF APPLIED ELECTRICITY.—A Practical Guide for Electricians, Mechanics, Engineers, Students, Telegraph and Telephone Operators, and All Others Interested in Electricity. Prepared by a Corps of Experts, Electrical Engineers and Designers. In Five Parts. Chicago, Ill.: American School of Correspondence. Cloth; 7 × 10 ins.; pp. 2,143; over two thousand illustrations, mostly in the text. List price, $30; Special Introductory price, $18.

Part I. Current Measurements, Wiring, Telegraph. Pp. 424.
Part II. Dynamos, Motors, Storage Batteries. Pp. 422.
Part III. Lighting, Railways, Power Stations. Pp. 409.
Part IV. Alternating Currents, Power Transmission. Pp. 490.
Part V. Telephony, Index. Pp. 398.

FUEL-TESTING PLANT OF THE UNITED STATES GEOLOGICAL SURVEY.—Washington, D. C.: U. S. Geological Survey. Charles D. Walcott, Director. Paper; 6 × 9 ins.; pp. 13.

GEOLOGIC ATLAS OF THE UNITED STATES.—Kittanning (Pa.) Folio, No. 115. Washington, D. C.: U. S. Geological Survey. Stiff Paper, Cloth Back; 18½ × 22 ins.; pp. 15; 7 plates and 8 figures in the text.

HOW TO HANDLE FREIGHT.—Address to the Agents and Employees of the Chicago & Northwestern Railway Company, Delivered at Chicago, Boone, North Fond du Lac, Madison, Escanaba, Waseca and Huron. By R. C. Richards. (Chicago: General Claim Agent, Chicago & Northwestern Railway Co.) Cloth; 5 × 7 ins.; pp. 67.

MODERN CIVIC ART.—Or the City Made Beautiful. By Charles Mulford Robinson, Author "The Improvement of Towns and Cities. Second Edition, with Illustrations. New York and London: G. P. Putnam's Sons. Cloth; 7 × 10 ins.; pp. 381; 30 plates. $3.00, net; by mail, $3.20.

POOR'S DIRECTORY OF RAILWAY OFFICIALS (STEAM, ELECTRIC AND OTHER).—Containing Lists of the Officials of all the Railroads in Operation in the United States, Canada and Mexico. Edition of January, 1905. A Supplement to Poor's Manual of Railroads. Nineteenth Annual Compilation. New York: Poor's Railroad Manual Co. Paper; 6 × 9 ins.; pp. xxxiv. + 132 + 54.

PROFESSIONAL PAPERS OF THE U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 9 × 12 ins.

No. 35: The Geology of the Perry Basin in Southeastern Maine. By George Otis Smith and David White. Pp. 107; six plates in the text.

SANITARY LAW AND PRACTICE.—A Handbook for Students. By W. Robertson, M. D. (Glas.), D. P. H., Medical Officer of Health, Leith; and Charles Porter, M. D., B. Sc., Lecturer on Bacteriology, University College, Sheffield; Deputy and Assistant Medical Officer of Health, City of Sheffield. London: The Sanitary Publishing Co., Ltd. Cloth; 6 × 9 ins.; pp. xxiii. + 756; 81 figures in the text. 10½ shillings; postage 4d. American price, $4.20.

SOCIALISM.—Containing a Discussion of the Relations of Capital and Labor. By Henry Apthorp. Cleveland, O.: The Author (442 The Arcade). Paper; 6 × 9 ins.; pp. 31; illustrated. 10 cts.

DIE STEUERUNGEN DER DAMPFMASCHINEN.—(The Valve Gears of Steam Engines). By Carl Leist, Professor in the Berlin Technical College. Second Revised and Much Enlarged Edition and the Fifth Edition of the Work of the Same Name by Emil Blaha. Berlin: Julius Springer. Cloth; 6 × 9 ins.; pp. xviii. + 940; 553 figures in the text. 20 marks; in the United States, $8.

THE TESTING OF CONTINUOUS CURRENT MACHINES IN LABORATORIES AND TEST-ROOMS.—A Practical Work for Students and Engineers. By Charles Kinzbrunner, Assoc. M. Inst. E. E., Lecturer on Electrical Engineering and Design at the Municipal School of Technology, Manchester. New York: John Wiley & Sons. Cloth; 6 × 9 ins.; pp. 326; 249 illustrations in the text. $2.